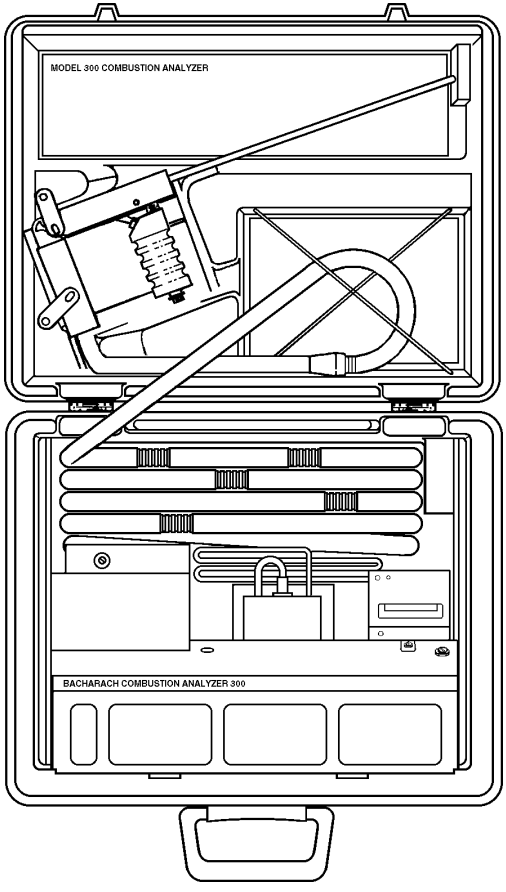
BACHARACH®

INSTRUCTION 24-9223
MODEL 300
COMBUSTION ANALYZER

(Standard Efficiency Equations, Siegert Efficiency Equations, and NSX Version)

Operation/Maintenance
Rev. 2 – November 1999



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NOTE: *O-Rings and Gaskets are considered consumable items and are excluded from the terms of this warranty.*

WARNINGS!

- *Burn hazard. DO NOT touch the Model 300 Combustion Analyzer probe after it is removed from a stack. Allow the probe to cool before handling.*

- *Burn hazard. When emptying filter/trap bowl and particulate trap, be aware that both traps may contain hot and mildly corrosive water. Take the necessary precautions to avoid being burned.*

- *Burn hazard. All of the sensors contain corrosive chemicals. DO NOT puncture or take them apart.*

CAUTIONS:

- *To avoid damaging the probe assembly due to excessive heat, remove probe from stack at or before the prescribed time listed below. Allow probe to cool to room temperature before reinserting it back into the stack.*

  100–1000°F (38–538°C) ..... Unlimited
  1000–1200°F (538–649°C) ..... 30 mins. per exposure
  1200–1400°F (649–760°C) ..... 10 mins. per exposure

  Note that the high-temperature extended-probe options have unlimited exposure times up to 2000°F (1093°C)

- *Allow probe to cool before placing it in case.*

- *DO NOT store the Model 300 Combustion Analyzer at temperatures below – 4°F (– 20°C).*

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SPECIFICATIONS

GENERAL

Size	Carrying Case: 18" x 14" x 8" (45.7 x 35.6 x 20.3 cm) Standard Probe: 11.5" (29.2 cm)* Hose - 22' (6.7 m)*
Weight	15 lbs. (6.8 kg)
Materials	HDPE Case, medium gray; polycarbonate membrane switch; stainless steel probe
Calibration Interval	60 seconds
Storage Environment	–4 to 122°F (–20 to 50°C), 0 to 100% relative humidity
Operating Environment	32 to 104°F (0 to 40°C), 0 to 99% relative humidity, non-condensing.
Sample Gas Flow	0.7 to 1.5 liters/min
Power source	Either 120 VAC, 240 VAC, or internal battery pack per sales order

BATTERY PACK SPECIFICATIONS

(A battery-powered unit may be run off the charger, if required.)

Output Voltage:	5 VDC
Charging Input Voltage:	8 VDC from Bacharach Charger (Refer to Section 6 for part numbers)
Charging Time:	5-6 hours
Operating Time	At least 200 sequential combustion tests, or 4 to 6 hours (min.). The analyzer will operate an addtional 1 hour (min.) after the BATTERY STATUS light goes out. *These discharge times are based on worst-case-continuous-operating conditions, which include printing every 20 minutes. A typical discharge time of a fully charged battery pack is between 12 and 16 hours.*

ACCURACY (68°F [20°C], 45% RELATIVE HUMIDITY)

Stack Temperature ..... ±1% full scale
Oxygen ..... ±0.6% O_2
Carbon Monoxide ..... ±5% reading or ±10 ppm, whichever is greater
NO_X (Optional) ..... ±5% reading or ±10 ppm, whichever is greater
SO_2 (Optional) ..... ±5% reading or ±10 ppm, whichever is greater

PROBE TEMPERATURE EXPOSURE LIMITS

The time and temperature limits for the probe assembly (24-7131) are listed below.

Stack Temperature	Probe Exposure Time Limit
100–1000°F (38–538°C)	Unlimited
1000–1200°F (538–649°C)	30 mins. per exposure
1200–1400°F (649–760°C)	10 mins. per exposure

NOTE: *The high-temperature extended-probe options have unlimited exposure times up to 2000°F (1093°C).*

FUNCTIONS

Directly Measures and Displays:

- Stack Temperature (up to 2000°F [1093°C])
- Carbon Monoxide level: (0–3700 ppm over 32–104°F [0– 40°C])
- Oxygen level (0.1 to at least 23.5%)
- Oxygen Sensor output in millivolts
- NO_X level (0-1999 ppm) (NSX units)
- SO_2 level (0-1999 ppm) (NSX units)

FUNCTIONS (Cont.)

Computes and Displays:

- Combustion Efficiency (1 to 99.9%)
- Stack Loss (1 to 99.9%)
- Carbon Dioxide Level (1 to 20%)
- Excess Air (1 to 250%)

Additionally Displays:

- Fuel selected:

Standard Efficiency Equations

NGAS - Natural Gas
OIL2 - Number Two Fuel Oil
OIL6 - Number Six Fuel Oil
LPG - Liquid Propane
COAL - Coal
WOOD - Wood (17% Moisture)
BAGA - Bagasse (from vegetable matter)

Siegert Efficiency Equations

NG+F - Natural Gas w/ Fan
NG–F - Natural Gas w/o Fan
LOIL - Light Oil
HOIL - Heavy Oil
LPG - Liquid Propane
KOKS - Coal Gas
LEG - Low Energy Gas

***** Custom fuels available upon factory request.

FUNCTIONS (Cont.)

Additionally Displays (Cont.):

- Analyzer errors or warnings

Main Display

OK	-	No errors or warnings to report.
W*CO	-	CO channel warning.
E*O2	-	Oxygen channel error.
E*TC	-	Thermocouple channel error.
E*AM	-	Ambient temperature channel error.
OR/A	-	Ambient sensor overrange.
OR/T	-	Thermocouple overrange.
OR/C	-	CO sensor overrange.
OR/O	-	O_2 sensor overrange.

Auxiliary Display, NSX Units

LOW BATT	-	NO_X/SO_2 sensor bias batteries low.
BATT FAIL	-	NO_X/SO_2 sensor bias batteries dead.
W*NO	-	NO_X sensor out of calibration.
W*SO	-	SO_2 sensor out of calibration.
E*NO	-	NO_X sensor failure.
E*SO	-	SO_2 sensor failure.
****	-	Clock module battery dead.

Additional Printouts (NSX units only):

- Serial number of analyzer
- Time and date of test
- NO_X ppm level (if NO_X sensor is installed)
- SO_2 ppm level (if SO_2 sensor is installed)

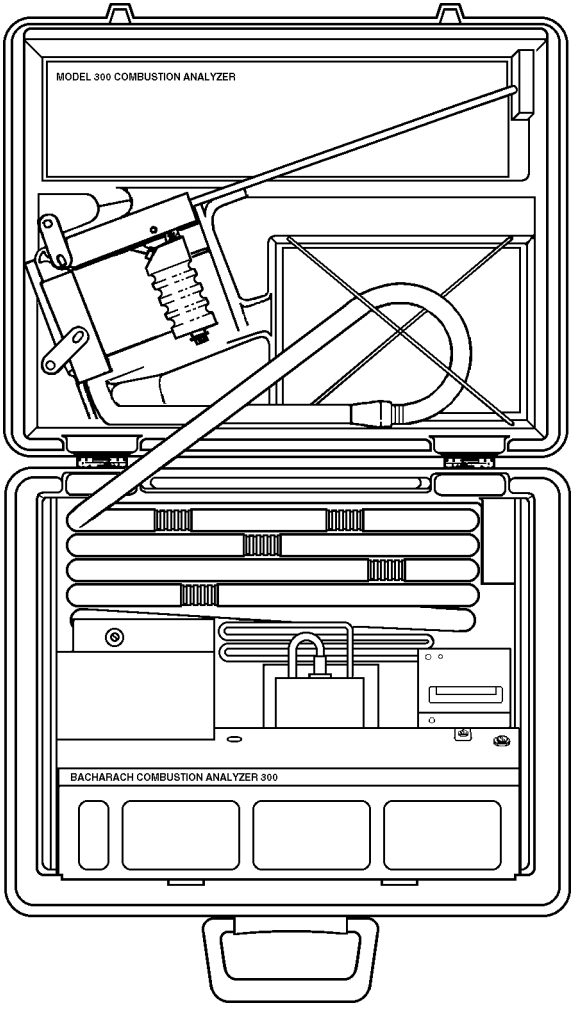


Figure A. Model 300 Combustion Analyzer (Typical Configuration)

1 INTRODUCTION

The Model 300 Combustion Analyzer is an efficiency analyzer designed for medium to large, condensing and non-condensing, industrial burners. A microprocessor controls the analyzer's operation along with calculating burner efficiency.

1.1 SCOPE OF MANUAL

The following information is provided in this manual:

1. INTRODUCTION	Describes the instrument, and its front panel controls
2. SET UP	Describes how to prepare a new analyzer for operation.
3. OPERATION	Describes how to perform a combustion efficiency test.
4. MAINTENANCE	Provides information about maintaining and caring for the instrument.
5. CALIBRATION	Describes how to calibrate the O_2 and CO sensors as well as optional NO_X and SO_2 sensors, plus the temperature channel.
6. PARTS, ACCESSORIES AND DIAGRAMS	List of replaceable parts and optional accessories, plus wiring diagrams.
GLOSSARY	Description of the technical terms used in this manual.

1.2 BASIC FEATURES

Three large LED readouts display the following information about both the combustion process being analyzed, and the instrument itself:

- O_2 Cell Output (mV)
- Analyzer Errors
- Stack Temperature (°F /°C)
- CO Level in ppm
- % Efficiency
- % Excess Air
- % Loss
- % O_2
- % CO_2

Because the Model 300 Combustion Analyzer is a "smart" instrument, its operation is fast and virtually mistake-proof. Programmed routines lead the operator through the proper sequence of start-up and test procedures, signaling what action is required, and locking the instrument into a waiting mode until the proper action is taken.

The instrument's microprocessor is programmed to compute percent efficiency, percent excess air, and percent carbon dioxide for the seven fuels described in Table 2 (in the front of this manual).

In addition to the instrument's microprocessor control and display circuitry, the following items are also provided with each Model 300 Combustion Analyzer inside its suitcase style carrying case:

- Particulate trap wrench.
- AC power supply, or battery pack with charger.
- Air-filter/water-trap with three replacement filters.
- Optional printer with one extra roll of paper.
- Instruction manual.
- O_2 and CO sensor.
- On analyzers supplied with a probe and hose:
  - 11 inch rigid probe with integrated particulate trap (optional extended-length, high-temperature probes are also available).
  - 22 feet of hose and thermocouple wire (optional extended lengths of hose and thermocouple wire are also available).

1.3 OPTIONAL FEATURES

- **Printer,** prints out a copy of the efficiency test results.

The NSX version of the Model 300 Combustion Analyzer adds the following features (For information on upgrading to NO_X and/or SO_2, contact your distributor or the factory):

- **Real time clock**, providing front panel hour and minute display of the time in either a 12 or 24 hour format.

- **Display of the NO_X gas (oxides of nitrogen)**, present in sampled gas.

- **Display of SO_2 gas (sulfur dioxide)**, present in sampled gas.

- **Additional printout information**:

  - Time and date of test.
  - Serial number of analyzer.
  - NO_X level (if NO_X sensor is installed).
  - SO_2 level (if SO_2 sensor is installed).
  - A customized 20 character message.*

- **Foreign language printout (NSX models only)**, selectable via internal switches (refer to Section 5.8):

  - Standard Efficiency Equation versions: English, French, Spanish.
  - Siegert Efficiency Equation versions: English, French, German, Italian.

- **Full-time NO_X and SO_2**, sensor bias voltages that minimize sensor drift and warm-up time.

* Contact the factory or a Bacharach Service Center for details.

1.4 BASIC PANEL FUNCTIONS & DISPLAYS

1.4.1 CAL, FUEL, and RUN Keys

CAL

Press to start 60 second calibration cycle.

When left display shows CAL, the CAL key must be pressed before the analyzer can continue its operation.

FUEL

Press to either select or show the type of fuel to be used in the combustion efficiency calculations.

After the analyzer has completed its calibration sequence, the left display will show the word FUEL. At this time, the FUEL key is pressed until the type of fuel being burned is shown in the left display (See Table 2 in the front of this manual for a list of programmed fuels).

To display what fuel was chosen while an efficiency test is in progress, simply press the FUEL key.

To change fuels either during or after an efficiency test, press and hold the FUEL key and repeatedly press the left SELECT key until the desired fuel appears in the left display.

RUN

Press to start efficiency test. Press again to stop test.

When left display shows RUN, the RUN key must be pressed before the analyzer can continue its operation.

1.4.2 Left Display and Select Key

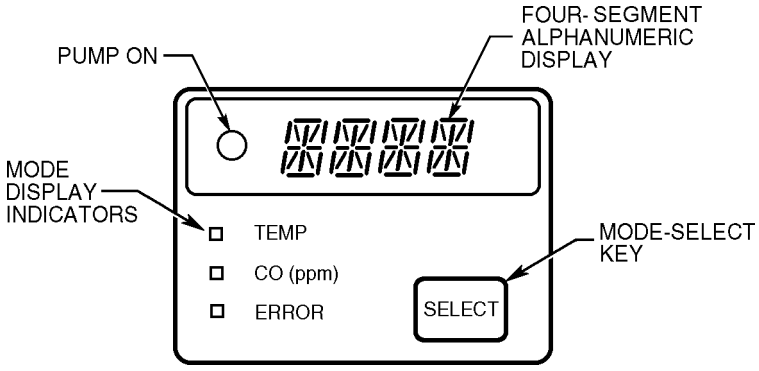


Figure 1-1. Left Display

SELECT

Press to show TEMP, CO (ppm), or ERROR information on the four-segment alphanumeric display. Also press with the FUEL key held down to change fuels after performing an efficiency test.

The Display Mode Indicators identify what is being shown on the display.

Display Mode Indicator Lit	Meaning of Display Indication
None	**CAL** – Combustion Analyzer in calibration mode. Press CAL key to start 60 second calibration cycle.
	FUEL – Combustion Analyzer awaiting fuel information. Press FUEL key until the fuel being burned is shown in the display (See Table 2 in the front of this manual).
	RUN – Combustion Analyzer ready to perform efficiency testing. Press RUN key to start test.

Display Mode Indicator Lit	Meaning of Display Indication
TEMP	Stack temperature detected by probe (°F or °C, see label inside case).
CO (ppm)	Carbon Monoxide concentration as measured by the CO sensor.
ERROR	**OK** – No errors or warnings to report. **W*CO** – Warning, CO sensor bad or trip limit of +115 ppm was detected during calibration. **E*O2** – Error, O_2 cell bad or missing. Occurs at end of calibration cycle if output of O_2 cell is either less than 15.1 mV or greater than 65.9 mV. **E*TC** – Error, thermocouple temperature is below –100° or above 2300°F (–148° & 1260°C). **E*AM** – Error, instrument temperature below or above its operating temperature range of 32° to 122°F (0° to 50°C). **OR/C** – CO channel overrange. **OR/A** – Ambient temperature overrange. **OR/T** – Thermocouple channel overrange. **OR/O** – O_2 channel overrange, O_2 CELL indication has exceeded 74.4 mV.

The Pump On indicator lights whenever the pump is running.

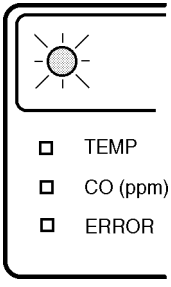


Figure 1-2. Pump ON Light

1.4.3 Middle Display and Select Key

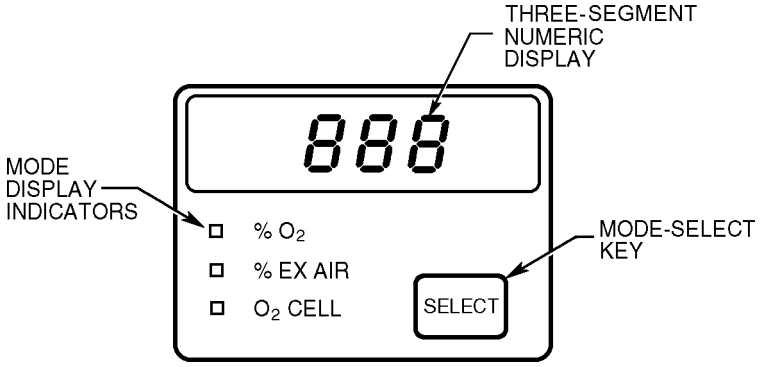


Figure 1-3. Middle Display

SELECT Press to show $\%O_2$, % EX AIR, or O_2 CELL information on the three-segment numeric display.

The Display Mode Indicators identify what is being shown on the display.

Display Mode Indicator Lit	Meaning of Display Indication
% O_2	Oxygen percentage as measured by the O_2 sensor.
% EX AIR	Computed excess air percentage is based on the $\%O_2$ detected, the fuel selected, and on the amount of CO measured. The display shows three dashes if $\%O_2$ is above 15%.
O_2 CELL	Millivolt output of O_2 Cell. If indication is below 18 ***while sampling fresh air***, the O_2 cell is nearing the end of its useful life and should be replaced soon.

1.4.4 Right Display and Select Key

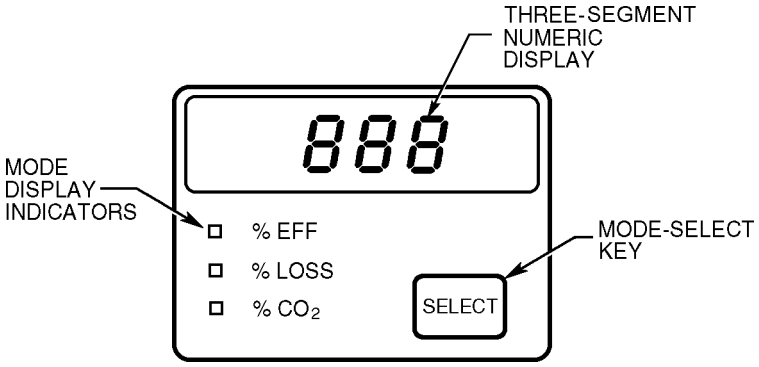


Figure 1-4. Right Display

SELECT Press to show %EFF, %LOSS, or $\%CO_2$ information on the three-segment numeric display. The Display Mode Indicators identify what is being shown on the display.

Display Mode Indicator Lit	Meaning of Display Indication
None	Counts down 60 second calibration time.
% EFF	Combustion efficiency percentage. Computed value based on $\%O_2$ detected, CO detected, net stack temperature measured, and fuel selected. Display shows three dashes if $\%O_2$ is above 15%.
% LOSS	Stack loss percentage. Computed value based on $\%O_2$ detected, CO detected, net stack temperature measured, and fuel selected. Display shows three dashes if $\%O_2$ is above 15%.
% CO_2	Carbon dioxide percentage. Computed value based on $\%O_2$ detected, CO detected and fuel selected. Display shows three dashes if $\%O_2$ is above 15%.

1.5 OPTIONAL AUXILIARY PANEL FUNCTIONS & DISPLAYS

Functions of the three display windows on the auxiliary display panel are described in Sections 1.5.1 thru 1.5.3 below.

> **NOTE:** *With or without an NO_X (middle display) and/or SO_2 (right display) sensor installed, each display shows warning, failure, and error messages (refer to Section 3.5) that pertain to the NSX portion of the analyzer.*

1.5.1 Left Display - Clock

Shows current time in hours and minutes in either a 12 or 24 hour format. Refer to Section 2.7 for information on how to set the clock.

1.5.2 Middle Display - ppm NO_X

When an NO_X sensor is installed, the middle display shows the measured concentration of gaseous NO_X during an efficiency test.

1.5.3 Right Display - ppm SO_2

When an SO_2 sensor is installed, the right display shows measured concentration of gaseous SO_2 during an efficiency test.

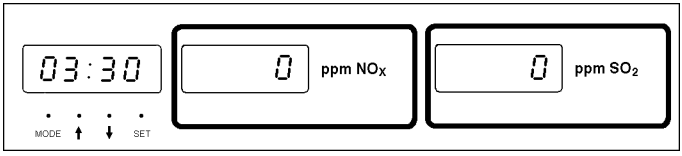


Figure 1-5. Optional Auxiliary Display Panel

NOTES

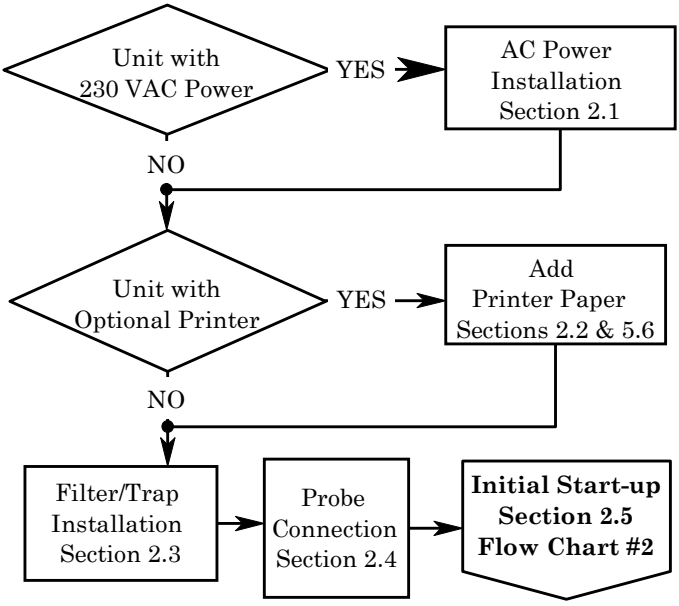
2 SET-UP

The charts and procedures in this section describe how to set-up the Model 300 for combustion efficiency testing. If any difficulty is encountered while performing these procedures, please refer to Section 4 and/or 5 for assistance in resolving the problem.

Before using the Model 300 preform all the following that apply:

- AC Plug Installation
- Printer Paper Installation
- Filter/Trap Installation
- Probe Connection
- Initial Start-up and Alignment
- Sensor Checks
- Optional Clock Setting
- Optional Analyzer Configuration

Flow Chart #1
SET-UP
Sections 2.1 - 2.4



2.1 230 VAC PLUG INSTALLATION

Due to the many different AC receptacles available for 230 VAC, a wall plug is not supplied on the instrument's 230 VAC power supply. An IEC receptacle is provided for the input. An IEC 380 cord set must be obtained, with the proper type of AC wall outlet, for the country where the instrument is to be used.

2.2 PRINTER PAPER INSTALLATION

Before turning on the analyzer, ensure that the printer has a roll of printer paper installed (Refer to Section 5.6).

2.3 FILTER/TRAP INSTALLATION

See Fig. 2-1. Press the latch on the filter/trap socket, located at the rear of the analyzer's control panel; then insert the O-ring end of the filter/trap into the socket and release the latch.

NOTE: *The bowl must be facing toward the bottom of case as shown to properly collect water.*

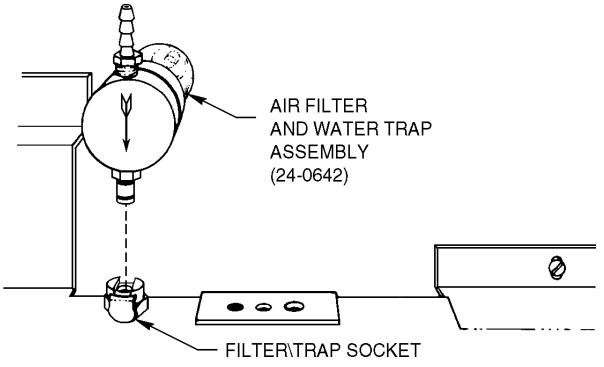


Figure 2-1. Filter/Trap Installation

2.4 PROBE CONNECTION

See Fig. 2-2. To connect the probe, simply attach its air tubing to the filter/trap, and plug its thermocouple connector into the receptacle at the rear of analyzer's control panel, noting the polarity of the connector.

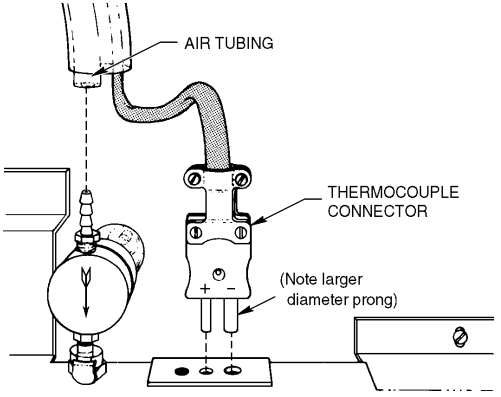
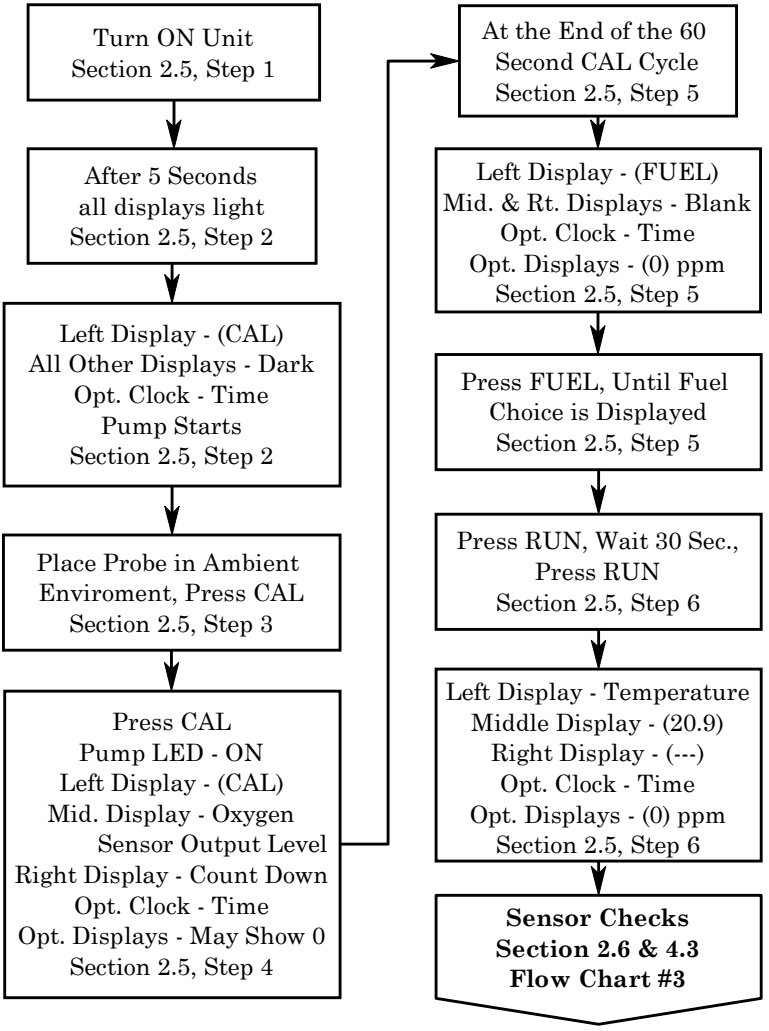


Figure 2-2. Probe Installation

2.5 INITIAL START-UP AND ADJUSTMENT

Flow Chart #2
INITIAL START-UP
Section 2.5 & 4.3



Before using your Model 300 Combustion Analyzer in an actual efficiency test, verify that the analyzer indicates 20.9% oxygen in fresh air, and correctly measures ambient air temperature.

1. Turn on the analyzer by either plugging it in, or by setting its battery pack switch (see Fig. 3-9) to ON.

2. Observe that all front and Optional auxiliary-display panel LEDs light for 3-5 seconds; after which, the left display shows CAL, the Optional clock display shows the correct time, and the middle and right front and Optional auxiliary-displays go dark. Also note the pump starts and continues to run until the conclusion of the calibration cycle.

3. Place the probe in an ambient (room) environment.

4. Press CAL key. At this time you should see (Fig. 2-3):

   - Pump LED turns on in left display.
   - Left display shows CAL.
   - Middle display show the oxygen sensor's millivolt output level.
   - Right display counts down calibration time starting at 60 seconds.
   - Optional clock will display the correct time.

   During calibration, Optional NO_X and SO_2 displays may not show zero. At the end of CAL cycle, these displays should indicate zero ±2 ppm.

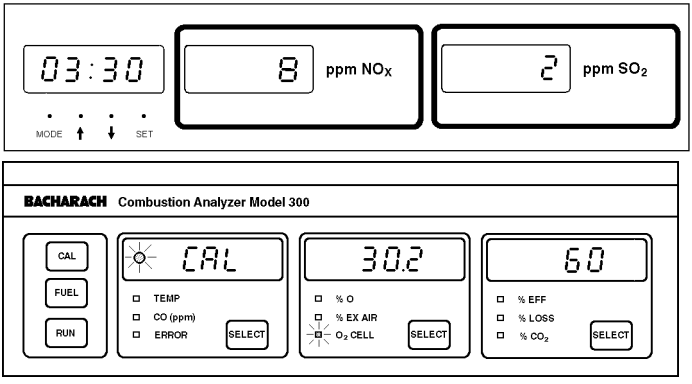


Figure 2-3. Typical Display During CAL Cycle

5. At the end of the calibration cycle, the left display should show FUEL, with the middle and right displays blank, the Optional clock will show the time, and Optional auxiliary panel middle and right displays will read 0 ppm. Now press the FUEL key until the left display shows your choice of any one of the analyzer's seven programmed fuels.

6. Press RUN key to start pump. Allow pump to run for 30 seconds; after which, stop pump by again pressing the RUN key. Then check for the following (Fig. 2-4):

   - Left display should show a temperature that is within ±2° of the actual room temperature. (*Temperature indication is in either °F or °C. To change temperature scale, move jumper W1 on connector J4 per Fig. 6-1A.*).
   - Middle display should show a $\%O_2$ indication of 20.9.
   - Right display should show three dashes.
   - Optional clock reads the correct time.
   - Optional auxiliary panel middle and right displays read 0 ppm.

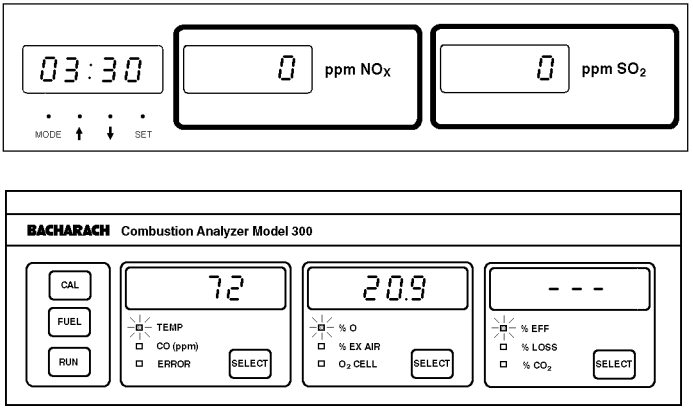
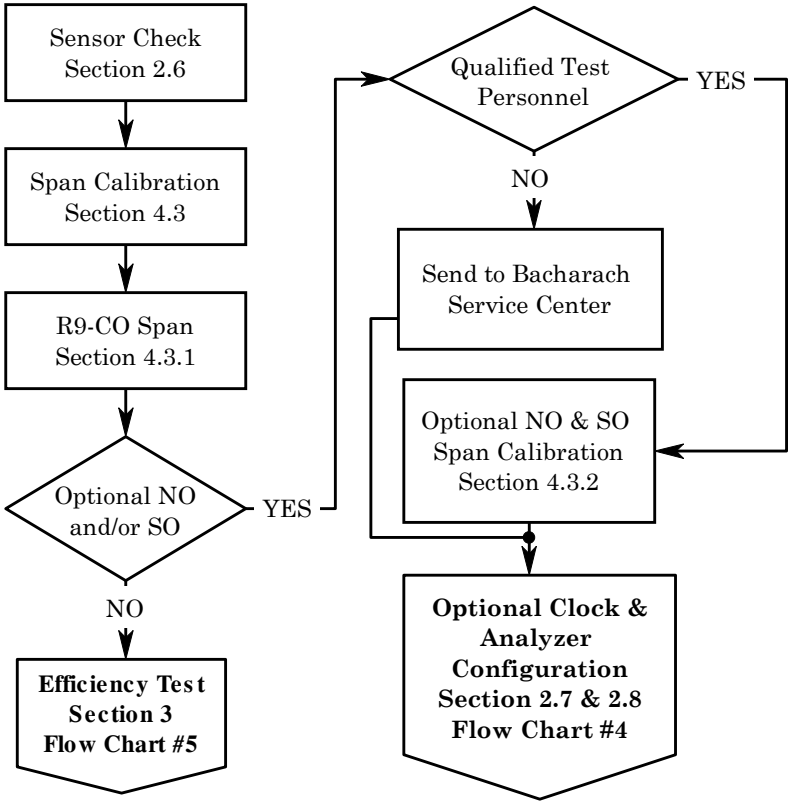


Figure 2-4. Display Indications After a Run Under Ambient Conditions

2.6 SENSOR CHECKS

Flow Chart #3
SENSOR CHECKS
Section 2.6 & 4.3



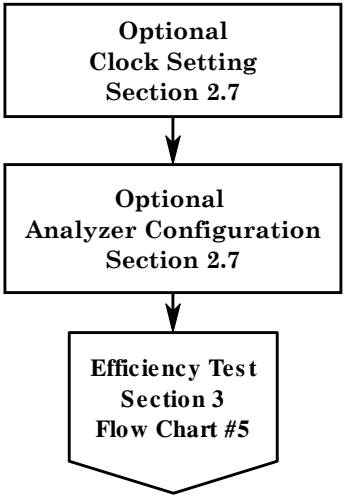
A new analyzer has all sensors installed and calibrated at the factory; however, you should ensure that the sensors are still in calibration before performing your first combustion efficiency test.

To *check* that the CO sensor is operating, follow the calibration procedure described in Section 4.3 "*CO Span Calibration*;" however, do not remove the control panel or make adjustments as instructed. The control panel needs to be removed only if the CO calibration pot needs adjustment.

Optional NO_X and SO_2 sensors are calibrated and installed at the factory and initially should not need a calibration check. Should you have reason to suspect the accuracy of either sensor, BACHARACH recommends that the unit be sent to a qualified Service Center (see the inside back cover) for calibration. If you have the qualified facilities and personnel to perform the calibration, see Section 4.3.2.

2.7 OPTIONAL CLOCK SETTING

Flow Chart #4
OPTIONAL CLOCK & ANALYZER CONFIGURATION
Sections 2.7 & 2.8



For correct time and date of an efficiency test to appear on the printout, the clock on the NSX auxiliary-display panel must be set as follows:

1. Open the analyzer case, and then flip up the auxiliary-display panel.

2. Apply power to the analyzer and wait until the main control panel's left display shows CAL. **DO NOT press the CAL key at this time.**

   The clock settings cannot be changed while the analyzer is calibrating or running an efficiency test. The clock settings can also be viewed and changed when the RUN or FUEL message is displayed.

3. See Fig. 2.5. Using the end of a straightened paper clip, or similar object, press the clock's MODE switch to cycle through the clock-mode settings. The following example shows what will be shown in the clock display after each depression of the MODE switch for: Sunday, the 9th of April, 1995, 3:58 PM.

   You may need to pause briefly after pressing the MODE switch, or any other clock switch, as the microprocessor may require a second or two to acknowledge your action.

   - 3:58 or 15:58 (current time).
   - CK:24 (24 hour format mode) or
     CK:12 (12 hour format mode).
   - YR:95 (Year).
   - MO:04 (Month).
   - DY:09 (Day of month).
   - DA:SU (Day of week).
   - HR:15 (Hour shown in 24 hour format) or
     PM:03 (Hour shown in 12 hour format).
   - MN:58 (Minute).
   - 3:58 or 15:58 (current time).

4. To set the clock proceed as follows:

   a. Press the MODE switch until the clock display shows the clock mode you wish to change.

      The NO_X and/or SO_2 display blanks when the clock display is placed in any one of its clock modes.

   b. Press the up and down arrow switches until the clock display shows the correct clock-mode setting.

   c. Press the SET switch to save the new setting, and then observe that the display automatically cycles to the next clock mode.

      *If MODE is pressed instead of SET after actuating the up and down arrow keys, the new settings are **not saved**.*

If a setting is not changed, depressing the SET switch merely reconfirms that setting as it cycles you to the next setting – including exiting from that clock-set mode.

If a change is made to the time format (CK:12 or CK:24), the hour of the day (PM:__ or HR:__) will also need to be reset.

d. Repeat steps "a" thorough "c" until all clock modes are correct; then press the MODE switch until the clock display returns to the current time.

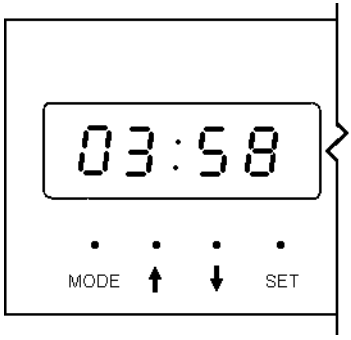


Figure 2-5. Clock Display Switches

2.8 OPTIONAL ANALYZER CONFIGURATION

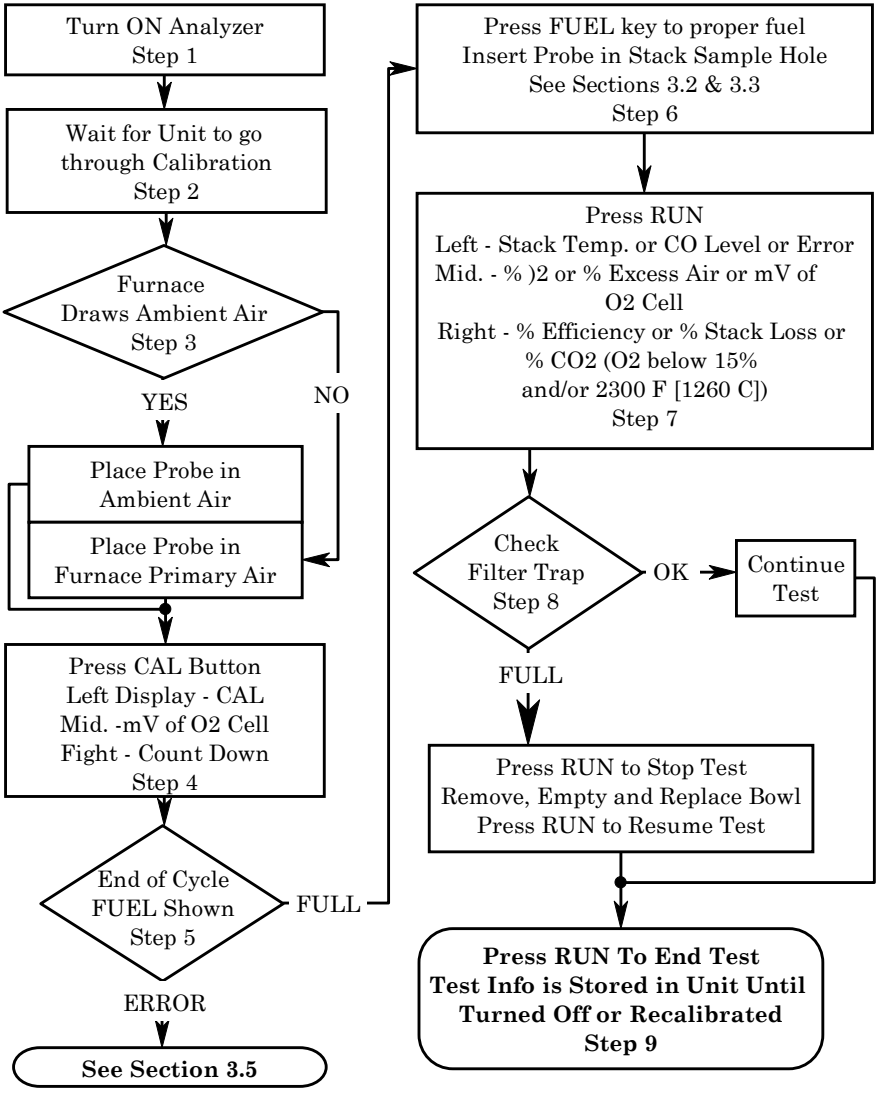
Analyzer configuration is determined by ten internal switches, **which should have been preset by the Bacharach Sales Center per the sales agreement.** If, however, a switch setting needs to be changed, refer to Section 5.8.

3 OPERATION

This sections describes:

- Performing an Efficiency Test
- Gas Sample Points
- Installing the Probe
- Printer Operation
- Error, Warning and Failure Displays
- Recalibration after an Efficiency Test
- Changing Fuels
- Combustion Analyzer Shutdown & Storage
- Changing the Battery Pack

Flow Chart #5
EFFICIENCY TEST
Section 3


Turn ON Analyzer
Step 1
Wait for Unit to go through Calibration
Step 2
Furnace Draws Ambient Air
Step 3
YES
NO
Place Probe in Ambient Air
Place Probe in Furnace Primary Air
Press CAL Button
Left Display - CAL
Mid. -mV of O2 Cell
Fight - Count Down
Step 4
End of Cycle FUEL Shown
Step 5
FULL
ERROR
See Section 3.5
Press FUEL key to proper fuel
Insert Probe in Stack Sample Hole
See Sections 3.2 & 3.3
Step 6
Press RUN
Left - Stack Temp. or CO Level or Error
Mid. - %)2 or % Excess Air or mV of O2 Cell
Right - % Efficiency or % Stack Loss or % CO2 (O2 below 15% and/or 2300 F [1260 C])
Step 7
Check Filter Trap
Step 8
OK
Continue Test
FULL
Press RUN to Stop Test
Remove, Empty and Replace Bowl
Press RUN to Resume Test
Press RUN To End Test
Test Info is Stored in Unit Until Turned Off or Recalibrated
Step 9

3.1 PERFORMING AN EFFICIENCY TEST

This procedure describes how to initially calibrate the Model 300 Combustion Analyzer and perform a combustion efficiency test.

Each time the combustion analyzer is turned on, its microprocessor begins its initial start-up routine. This routine directs the operator to calibrate the analyzer and select the proper fuel.

After performing an efficiency test, the analyzer can be recalibrated and/or a different fuel can be selected for the next test. Refer to Sections 3.6 and 3.7.

1. Turn on the analyzer by either plugging it in, or by setting its battery pack switch to ON.

   WARNING!

   Use only UL or CSA approved grounded extension cords. Use of other cords may bring about a hazardous condition and voids the instrument's warranty. Ungrounded extension cords may cause erratic display indications.

2. During initial power up, all front panel, and Optional auxiliary panel displays and LED indicators are checked by being turned on for approximately 5 seconds; after which, the left display switches to show CAL, the Optional clock displays the correct time, and the Optional auxiliary displays go dark. Also at this time, the pump is turned on and continues to run until the analyzer is calibrated.

3. Place probe into center of furnace's primary air inlet (Section 3.2). If the furnace is drawing in ambient room air, you can sample room air for the purpose of determining the primary air temperature.

   NOTE: *During calibration, you can measure inlet air temperature by selecting TEMP on the left display.*

4. Press CAL key to start calibration cycle. The following should be seen:

   - Left display show CAL.
   - Middle display show millivolt output of O_2 cell. *Should the cell's output fall outside acceptable limits, an **E*O2** error will occur (Refer to Section 3.5).*
   - Right display counts down the calibration time starting at 60 seconds.

5. At the end of the calibration cycle, the left display will either show FUEL, or flash an error code.

   If FUEL is shown, repeatedly press the FUEL key until the fuel being burned is shown on the left display. See Table 2 in the front of this manual for a list of the seven fuels available for this section. If an error code is shown refer to Section 3.5.

6. Insert probe into the stack sample point (Sections 3.2 and 3.3).

CAUTION:

To avoid damaging standard probe assembly, due to excessive heat, remove probe from stack at or before the prescribed time listed in Table 1 in the front of this manual. Allow probe to cool before reinserting it back into the stack.

7. Press RUN key to start the efficiency test. Observe that the Pump On LED is lit and the word RUN momentarily appears in the left display before the display switches to show stack temperature.

   The combustion analyzer now continuously monitors the combustion process for as long as the analyzer is running. Use each display's associated SELECT key to observe the following:

   - Left display shows either stack temperature, carbon monoxide level, or combustion analyzer errors.
   - Middle display shows either % oxygen, % excess air, or millivolt output of O_2 cell.
   - Right display shows either % efficiency, % stack loss, or % CO_2, as long as O_2 is below 15% and/or stack temperature is below 2300°F (1260°C).

- Optional NOx and/or SO_2 concentrations are displayed on the auxiliary panel.
- Optional clock displays the current time.

NOTE: *It's normal for the Display Mode Indicators to occasionally blink due to the complexity of the efficiency calculations.*

8. During an efficiency test, periodically check the water level inside the panel-mounted filter/trap.

WARNING!

The liquid within the filter/trap bowl may be hot and mildly acidic.

If water begins to approach the trap's filter element, press RUN key to stop test. Remove filter/trap and empty its bowl (Fig. 3-1). When replacing the bowl, be sure its O-ring is properly installed, and the shield is properly oriented – improper installation can allow air to leak into gas sample and reduce accuracy of efficiency calculation. Reinstall filter/trap and press RUN key to resume testing.

9. To end an efficiency test, press RUN key to stop pump. All testing information is stored until analyzer is turned off or recalibrated.

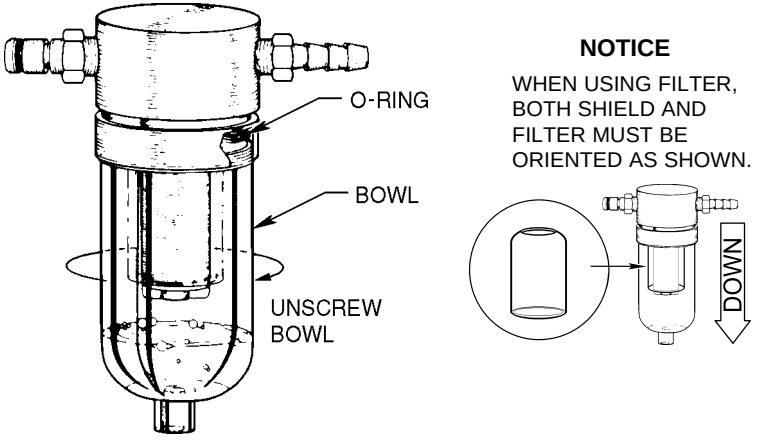


Figure 3-1. Filter/Trap Bowl Removal

3.2 GAS SAMPLING POINTS

The Model 300 Combustion Analyzer requires a 3/8" (9.5 mm) minimum diameter sampling hole to accommodate the analyzer's probe-stop.

Locate the sampling point downstream from the last heat exchanger, and upstream from any source of dilution.

> **Important:** *As the distance between the heat exchanger and the sampling point increases, the calculated combustion efficiency will falsely increase due to heat loss in the flue or stack.*

For residential and light commercial combustion equipment applications, the following recommendations are applicable:

- **Oil Burners** – Locate sampling hole at least 12" downstream from the furnace breeching, and at least 6" upstream from the furnace side of the draft regulator.
- **Gas Burners** – Locate sampling hole at least 6" upstream from the furnace side of the draft diverter on gas conversion units. For gas-designed equipment, the probe may be inserted down into the flue through the draft diverter or hood.

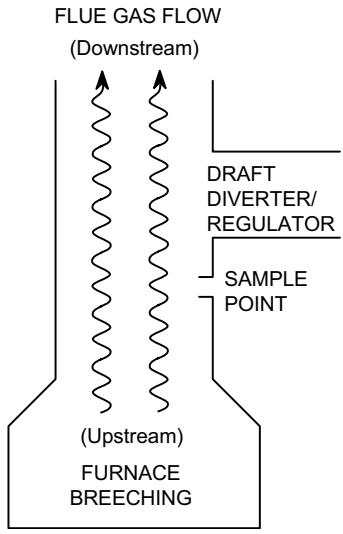


Figure 3-2. Sample Point

3.3 INSTALLING THE PROBE

Screw probe stop into gas-sampling hole (Fig. 3-3); then insert probe through hole in probe stop.

Push probe into stack to desired depth; then tighten probe-stop-thumb screw to lock probe in place.

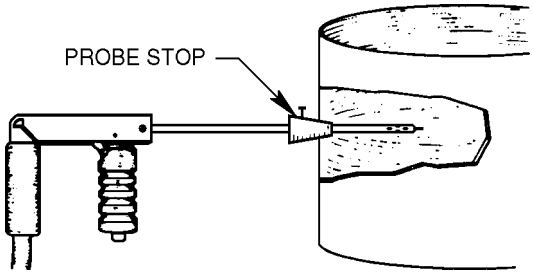


Figure 3-3. Installing the Probe

3.4 PRINTER OPERATION

Press the PRINT switch (Fig. 3-4) to obtain a hard copy of the efficiency test results either during an efficiency test, or after its completion – the printer will not operate at any other time. Observe that the PRINT LED will glow as the printer operates. Fig. 3-5 shows a typical printout.

> **NOTE:** *If the right display shows three dashes while printing, the numbers printed for % efficiency, % stack loss, and % carbon dioxide are invalid.*

After printing, press and hold the PAPER ADVANCE switch to advance paper before tearing. Advance paper as much as necessary to leave enough space for writing your comments at the end of the printout.

In the Optional units, each of the different language printouts can show the same information in the same sequence, except for the date. Most units show the date as month/day/year, while all Siegert units show the date as day, month, year.

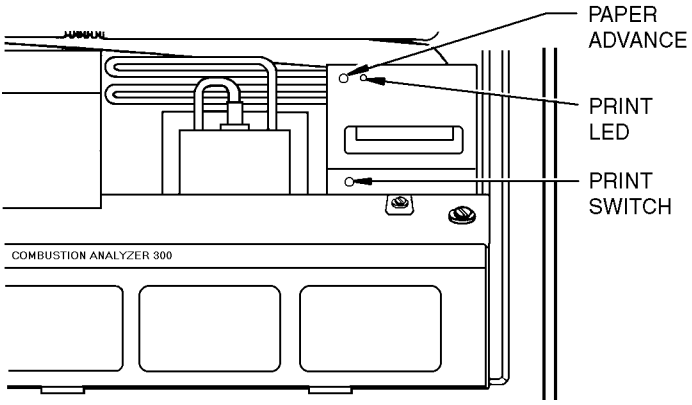


Figure 3-4. Printer Controls

BACHARACH MODEL 3ØØ

* * * * * * * * * * * *

COMBUSTION ANALYZER

ID: _____
DATE: _____
TIME: _____

FUEL:	NAT.GAS
PRIMRY TEMP <F>:	77
STACK TEMP <F>:	416
% OXYGEN:	8.3
% EXCESS AIR:	6Ø.Ø
% CARBON - DIOXIDE:	7.1
PPM CARBON - MONOXIDE:	Ø
% EFFICIENCY:	88.4
% STACK LOSS:	11.6

TEST PERFORMED BY:

_____

COMMENTS ....

BACHARACH
MODEL CA3ØØNSX

* * * * * * * * * * * *

COMBUSTION ANALYZER

ID: _____
SER. NO: VD0511
DATE: 11/16/95
TIME: 09:02

FUEL: NATURAL GAS

PRIMRY TEMP <F>:	75
STACK TEMP <F>:	76
% OXYGEN:	2Ø.9
% EXCESS AIR:	276
% CARBON - DIOXIDE:	.Ø
PPM CARBON - MONOXIDE:	Ø
PPM NOX:	-1
PPM SULFUR - DIOXIDE:	-1
% EFFICIENCY:	99.9
% STACK LOSS:	.1

TEST PERFORMED BY:

_____

COMMENTS ....

Figure 3-5. Typical Printouts

3.5 ERROR, WARNING AND OVERRANGE DISPLAYS

3.5.1 Basic Error, Warning and Overrange Displays

Three levels of problems are detected by the analyer's microprocessor, and then identified on the left display in the form of **E*** (error), **W*** (warning) and **OR** (overrange) messages. Refer to Table 3-1 for a listing and description of these messages.

Depending on the nature of the problem and mode of the analyzer, the analyzer behaves as follows when a problem occurs:

- If an "error" and/or "warning" problem occurs during the CAL cycle: the ERROR indicator starts flashing, and an **E*** and/or **W*** message appears at the *conclusion* of the calibration cycle.

- If an "overrange" problem occurs during the CAL cycle: the calibration cycle is *immediately* aborted, the ERROR indicator starts flashing, and an **OR** message appears.

- If an "error" and/or "overrange" problem occurs during an efficiency test: the efficiency test is *immediately* aborted, the ERROR indicator starts flashing, and an **E*** or **OR** message appears.

- "Warnings" are *ignored* during an efficiency test.

To acknowledge and clear an error, warning, or overrange message, perform the following:

1. Press the left SELECT key to acknowledge the **E***, **W***, or **OR** message, and to stop the ERROR indicator from flashing.

   If the analyzer reports more than one problem, continue to press the left SELECT key as many times as necessary to view and clear all messages, until either the analyzer starts through another calibration cycle, or the word RUN or FUEL appears in the left display.

2. If a recalibration cycle is started, allow the cycle to finish before proceeding.

   If RUN is displayed, press the RUN key to restart the efficiency test.

   If FUEL is displayed, press the FUEL key until the desired fuel is shown in the left display. Then press the RUN key to restart the efficiency test.

3. If the "error/warning/overrange" indication reappears after three attempts have been made to clear it, correct the problem(s) displayed in Step 1 by following the suggested remedies listed in Table 3-1.

3.5.2 Optional Error, Warning, and Overrange Displays

The warning, failure, and error messages listed in Table 3-2 are displayed on the auxiliary-display panel when an abnormality is detected within the NSX portion of the analyzer.

Since the detected values of NO_X and/or SO_2 are not used in the calculation of combustion efficiency, the analyzer will continue to operate and provide valid combustion efficiency test results when any of the messages listed in **Table 3-2** are displayed.

TABLE 3-1. Basic Error, Warning and Overrange Displays

Display Shows	Display Meaning	Remedy
OK	No errors, warnings or overranges to report.	-----
W*CO	Warning, CO level over 115 ppm after calibration.	Remove and then reapply power to the analyzer. Allow pump to run 5 minutes (longer if necessary) while sampling fresh air to purge the instrument of CO. Then press CAL.
	Warning, CO span potentiometer R9 misadjusted.	Adjust potentiometer R9. Refer to Section 4.3.
	Warning, CO sensor bad.	Replace CO sensor. Refer to Section 5.2.
E*O2	Error, O_2 Cell output voltage is outside its normal operating range.	Remove and then reapply power to the analyzer. Allow pump to run 5 minutes (longer if necessary) while sampling fresh air to purge instrument of O_2. Then press CAL.
	Error, O_2 Cell bad.	Replace O_2 Cell. Refer to Section 5.1.
E*AM	Error, ambient temperature below 32° or above 122°F (0° & 50°C).	Allow analyzer to stabilize at a temperature between 32° and 122° F (0° and 5° C).
	Error, ambient temperature calibrate potentiometer R24 misadjusted.	Adjust potentiometer R24. Refer to Section 4.2.

TABLE 3-1. Basic Error, Warning and Overrange Displays (Cont.)

Display Shows	Display Meaning	Remedy
E*TC	Error, thermocouple temperature below –100° or above 2300° F (–73° and 1260° C).	Allow thermocouple to stabilize at room temperature and then recalibrate the analyzer.
	Error, thermocouple span potentiometer R19 misadjusted.	Adjust potentiometer R19. Refer to Section 4.4.
	Error, thermocouple defective.	Replace probe assembly, or replace just the thermocouple. Use Fig. 5-4 as guide when replacing just the thermocouple.
OR/C	Overrange in CO channel.	Acknowledge and clear the overrange by pressing the left SELECT key until the left display shows either CAL or RUN. The analyzer will then automatically restart either its calibration or run sequence. If a CO or O_2 overrange condition reoccurs after two attempts to clear it, purge the analyzer's gas sampling system by removing and then reapplying power to the instrument. Allow pump to run 5 minutes (longer if necessary) while sampling fresh air. Then press CAL.
OR/A	Overrange in ambient channel.	
OR/T	Overrange in thermocouple channel.	
OR/O	Overrange in O_2 channel. O_2 CELL indication rose above 74.4 mV during calibration cycle or during normal operation.	

TABLE 3-2. Optional Error, Warning and Overrange Displays

Left Display	Middle Display	Right Display	Meaning of Display
	LOW	BATT	Warning – sensor bias battery voltage getting low. This message is displayed at the conclusion of the calibration cycle, and once every 10 seconds during an efficiency test. The NO_X and SO_2 displays may be incorrect.
	BATT	FAIL	Failure – sensor bias batteries are dead. The NO_X and SO_2 displays are disabled.
	W*NO		Warning – NO_X sensor out of calibration. Four stars (****) are printed on the NO_X line of the printout.
		W*SO	Warning – SO_2 sensor out of calibration. Four stars (****) are printed on the SO_2 line of the printout.
	E*NO		Error – NO_X sensor has failed. Four stars (****) are printed on the NO_X line of the printout.
		E*SO	Error – SO_2 sensor has failed. Four stars (****) are printed on the SO_2 line of printout.
****			Failure – clock module battery is dead. Print out will show incorrect time and date values.

3.6 RECALIBRATION AFTER AN EFFICIENCY TEST

If you are unsure about the calibration of the analyzer after performing an efficiency test, it can be recalibrated as follows:

> **NOTE:** *Recalibration is essentially the same as the initial power-up calibration cycle, with the exception that the recalibration cycle can be aborted at any time by pressing the CAL key.*

1. Remove probe from stack or flue.

2. If the probe is hot, allow the analyzer's pump to operate in the run mode until the probe stabilizes at room temperature.

3. Press RUN key to stop pump.

4. Place probe into the center of the furnace's primary air inlet. If the furnace is drawing in ambient air, you can sample room air for calibration purposes.

5. Press CAL key to start recalibration cycle. During recalibration, you should see:

   - Left display show CAL,
   - Middle display show millivolt output of O_2 cell,
   - Right display count down the calibration time.

6. At the end of a successful recalibration cycle, the left display should read FUEL.

   > **NOTE:** *If a **W*CO** warning occurred at the conclusion of the recalibration cycle, due to the CO sensor not being completely purged of flue gas, remove and then reapply power to the analyzer. Allow pump to run 5 minutes (longer if necessary) while sampling fresh air to purge instrument of CO; then press CAL.*

7. Press the FUEL key until the desired fuel appears in the left display. Then press the RUN key to start efficiency testing.

3.7 CHANGING FUELS

To change fuels after an efficiency test has been run, proceed as follows:

1. If not already stopped, stop the pump by pressing the RUN key.

2. Press and hold the FUEL key. The left display shows what fuel is presently being used in the combustion efficiency calculations.

3. While holding down the FUEL key, repeatedly press the left SELECT key until the desired fuel is shown in the left display.

3.8 COMBUSTION ANALYZER SHUTDOWN AND STORAGE

Proceed as follows to shut down and store your Model 300 Combustion Analyzer:

1. If not already stopped, press RUN key to stop the analyzer's pump.

WARNING!

Probe may be hot. To avoid burns, always handle the probe with heat-protective gloves.

2. Remove probe from the stack or flue, and seal the sampling hole.

CAUTION:

Before storing probe inside case, allow probe to cool.

3. To quickly cool the probe tube, draw cool ambient air through the tube by pressing the RUN key to restart the pump. Allow pump to run until probe reaches room temperature; then press RUN key to stop pump.

4. Unplug AC power cord and store in case, or set battery pack Power switch to OFF (see Figure 3-9).

5. Empty the panel-mounted filter/trap and the probe-mounted particulate trap as follows:

WARNING!

Both traps may contain hot and mildly acidic water. Take the necessary precautions to avoid being burned.

CAUTION:

When emptying traps, be careful not to spill water into the combustion analyzer case.

a. See Fig. 3-1. Remove filter/trap from control panel; then unscrew and empty its bowl. Replace bowl being sure its O-ring is in place; then store filter/trap in case.

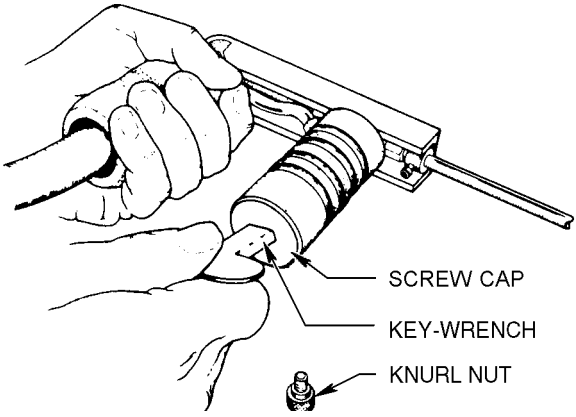


Figure 3-6. Particulate Trap Disassembly

b. Remove knurled nut (see Fig. 3-6), located at the bottom of the particulate trap, and empty trap of any water. Use key-wrench, supplied with the instrument, to unscrew the trap's screw cap. Clean trap, then replace screw cap being sure O-ring is in place.

6. After probe has cooled down to room temperature, store probe in lid of carrying case per Fig. 3-7.

7. Coil up and store probe hose in the bottom part of the carrying case. To avoid crimping the hose when the case is closed, loop hose under strap per Fig. 3-7.

8. Flip down optional display.

CAUTION:

DO NOT store the Model 300 Combustion Analyzer at temperatures below –4°F (–20°C).

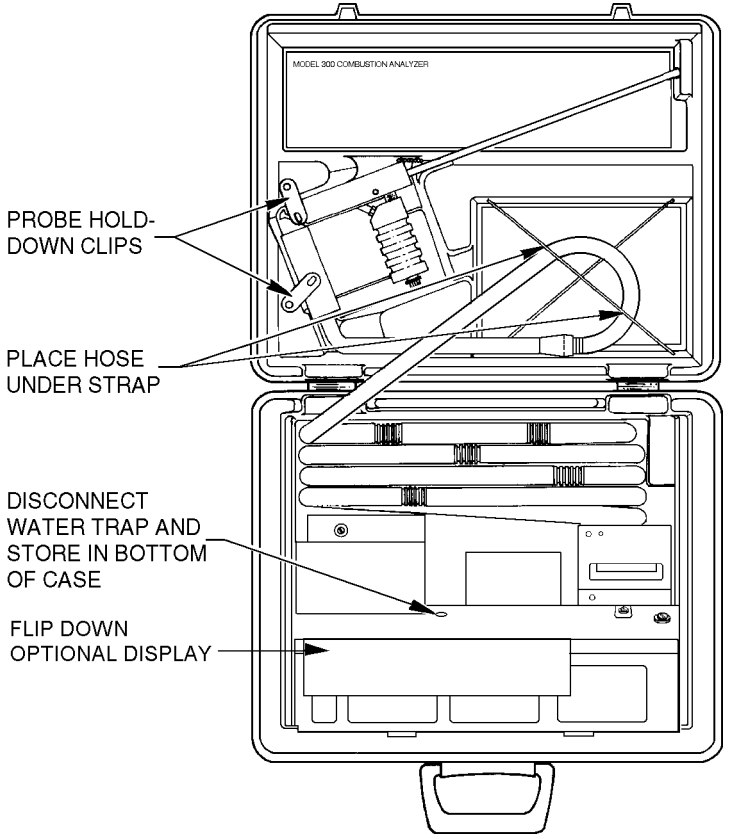

MODEL 300 COMBUSTION ANALYZER
PROBE HOLD-DOWN CLIPS
PLACE HOSE UNDER STRAP
DISCONNECT WATER TRAP AND STORE IN BOTTOM OF CASE
FLIP DOWN OPTIONAL DISPLAY

Figure 3-7. Storage of Combustion Analyzer Components

3.9 CHARGING THE BATTERY PACK

If the analyzer is powered by a battery pack, charge the pack as described below (also see Fig. 3-8).

A fully charged battery pack will run the analyzer through at least 200 combustion efficiency tests (6 hours minimum); although, typical operating time is between 12–16 hours. When the battery pack becomes discharged, its BATTERY STATUS LED turns off. The analyzer, however, will continue to operate for approximately 1 hour; after which, the pack's internal circuitry completely shuts down the analyzer to prevent a deep discharge of the pack's lead-acid batteries.

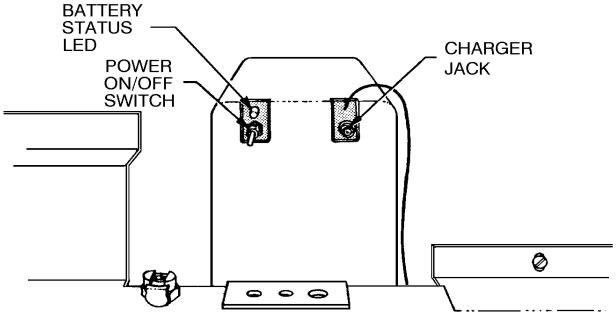


Figure 3-8. Battery Pack

Recharge the battery pack whenever its BATTERY STATUS LED no longer lights. The pack, however, can be recharged at *anytime*; you don't need to wait until the LED goes out before recharging. A circuit within the charger prevents overcharging by automatically switching to a trickle charge whenever the pack becomes fully charged.

Recharge the battery pack by first turning OFF the pack and connecting the charger that was supplied with the analyzer to the pack's CHARGER jack. Plug in the charger and allow the battery pack to charge a minimum of 16 hours if the pack was completely discharged. The instrument may be run indefinitely directly off of the recharger.

4 CALIBRATION

NOTE: *Analyzer calibration is available from authorized Bacharach Service Centers.*

This section describes how to check the combustion analyzer's calibration, and how to adjust the three potentiometers.

- Sensor and/or Control Panel Removal
- Ambient Temperature Adjust
- Toxic Gas Span Calibration
- Thermocouple Span Calibration
- Oxygen Sensor Calibration

The potentiometers should be adjusted whenever the analyzer is determined to be out of calibration using the procedures described in this section.

Calibration should be checked at least once a month, or whenever necessary as determined by experience.

To check calibration, follow the calibration procedures as described in this section, but *do not* remove the control panel or make adjustments as instructed. The control panel needs to be removed only to access the calibration potentiometers, and to remove the optional NO_X and SO_2 sensors.

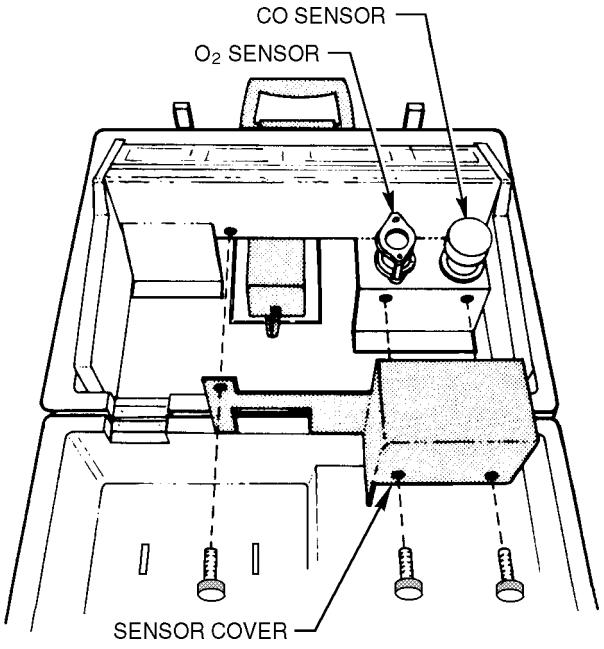


Figure 4-1. Removing Sensor Cover

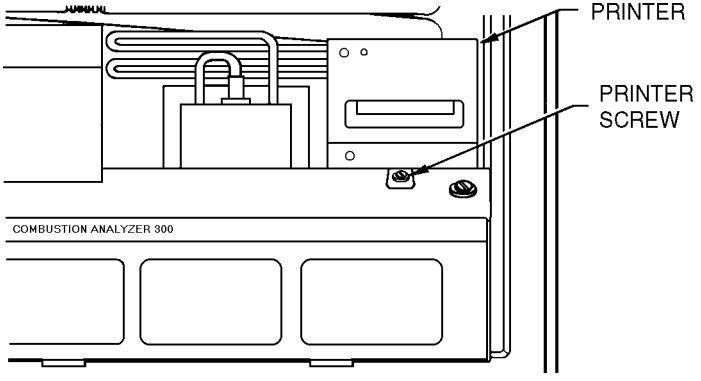


Figure 4-2. Printer Screw Location

4.1 SENSOR AND/OR CONTROL PANEL REMOVAL

To adjust potentiometers R9, R19, R24, POT1 & POT2, or to replace the sensors, the sensor and/or control panels must first be removed from the case as follows:

Equipment Needed

- Medium Flat-Blade Screwdriver

Procedure

1. Remove power from analyzer. If installed, fold down the Optional auxiliary display panel. Remove water trap by pressing the release tab and pulling on the trap (The water trap can remain attached to the air tubing). Disconnect the probe by removing the thermocouple connector from the analyzer's receptacle. Set the probe/trap assembly aside.

2. Remove sensor cover (Fig. 4-1) by loosening its three knurled screws.

   NOTE: *Only two knurled screws are used with the battery powered analyzers. At this point the O_2 and CO sensors are accessible.*

   If a printer is installed, remove the screw securing the printer to the control panel with a screwdriver (Fig. 4-2). Lift the printer straight up, then back to disengage from keyhole retainers. Set printer in case.

3. Remove the four screws securing the control panel (one located under the printer ribbon cable) to the case (Fig. 4-3). If the unit is equipped with an auxiliary panel, pull it straight up then turn it over and place the panel in the bottom of the case so that it is facing the back.

4. Tilt the control panel upwards so that the calibration pots and the front panel keys (or the sensors) are accessible (Fig. 4-4).

5. After the analyzer has been serviced, replace the control panel and auxiliary-display panel by reversing steps 1 thru 4.

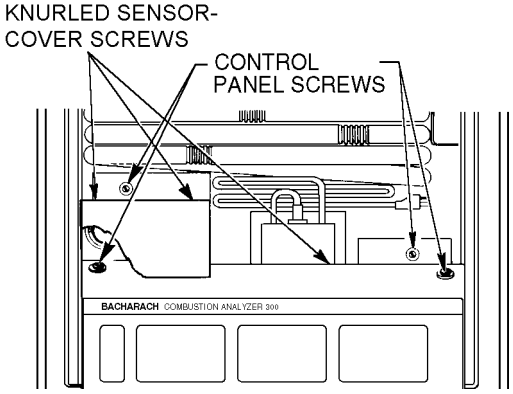


Figure 4-3. Screw Locations

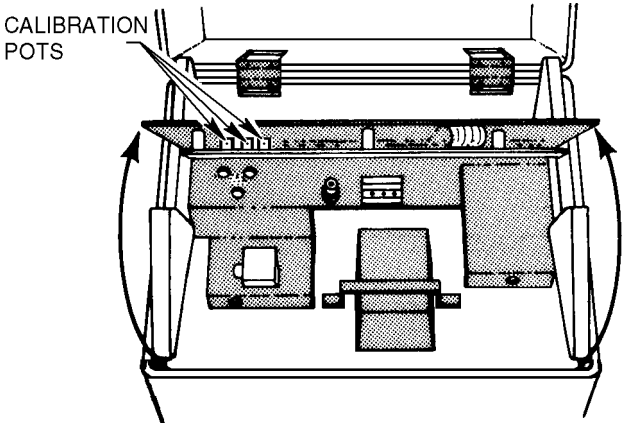


Figure 4-4. Accessing Control Panel Potentiometer (Typical Configuration)

4.2 AMBIENT TEMPERATURE CALIBRATION - R24

This procedure calibrates the combustion analyzer's ambient temperature transducer (component D7, mounted on the printed circuit board) to room temperature, using the R24 potentioneter (see Fig. 4-6).

Equipment Needed (See Section 6 for Part Numbers)

- Thermometer, precision grade, 0 to 220°F (–20 to 150°C)
- Potentiometer Adjustment Tool

Procedure

1. Remove control panel per Section 4.1.

2. Remove thermocouple plug from rear of analyzer (Fig. 4-5).

3. Ensure that the ambient (room) temperature is between 32° and 122°F (0° and 50°C); otherwise, an **E*AM** error will occur at the conclusion of the calibration cycle in Step 4 of this procedure.

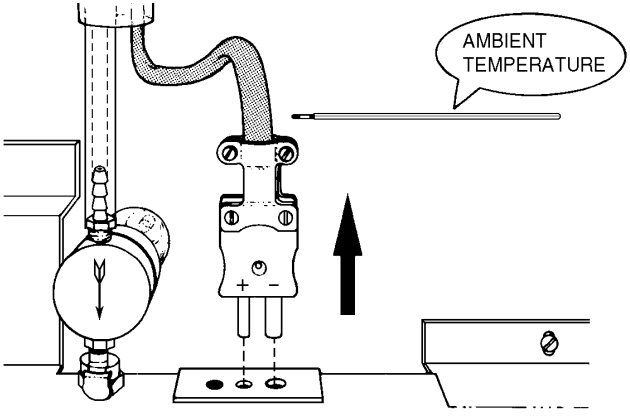


Figure 4-5. Ambient Temperature Calibration Setup

4. Power up the analyzer as follows:

   a. Turn on the analyzer by either plugging it in, or by setting its battery pack switch to ON.

   b. Press CAL key to start the 60 second calibration cycle.

   c. When the word FUEL appears on left display, press FUEL key to select any one of the seven fuels.

   d. Press RUN key to start analyzer.

5. Press the left SELECT key until TEMP indicator is lit.

6. The left display is now showing ambient room temperature as measured by the analyzer's ambient transducer. Compare this reading to the temperature on a thermometer measuring room temperature.

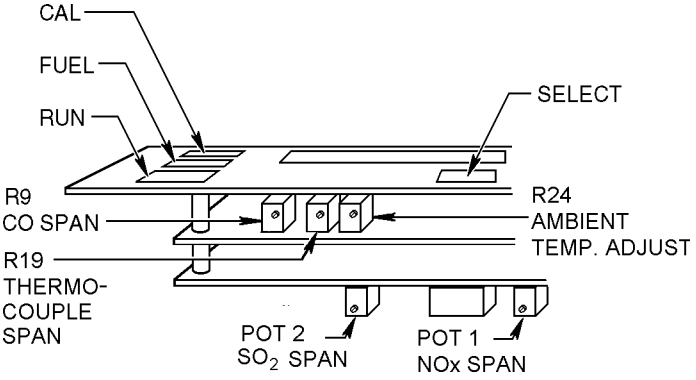


Figure 4-6. Span Potentiometer Locations

7. Using a potentiometer adjustment tool, adjust Ambient Temperature Adjust pot R24 (Fig. 4-6) until the analyzer's temperature readout matches the thermometer's room temperature indication.

8. Press RUN key to stop analyzer; then insert thermocouple plug back into control panel.

9. If no other calibration adjustments are to be made, replace the control panel and printer (if applicable).

4.3 TOXIC GAS SPAN CALIBRATION

The following procedure calibrates the combustion analyzer's sensors to a known concentration of gas.

4.3.1 CO Span Calibration - R9

Equipment Needed (See Section 6 for Part Numbers)

- Calibration Kit
- Potentiometer Adjustment Tool
- Carbon Monoxide Gas Cylinder, 500 ppm

Procedure

WARNING!

Perform this procedure in a well ventilated area. CO is toxic!

1. Remove control panel per Section 4.1.

2. Remove filter/trap from the analyzer's Gas Inlet Port, located on rear of control panel.

3. Connect the Carbon Monoxide Gas Cylinder and the Calibration Kit together as shown in Fig. 4-7.

   NOTE: *Make sure to leave the calibration setup disconnected from the analyzer at this time.*

4. Power up the analyzer as follows:

   a. Turn on the analyzer by either plugging it in, or by setting its battery pack switch to ON.

   b. Press the CAL key to start the 60 second calibration cycle.

   c. When the word FUEL appears on left display, press the FUEL key to select any one of the seven fuels.

   d. Press the RUN key to start pump.

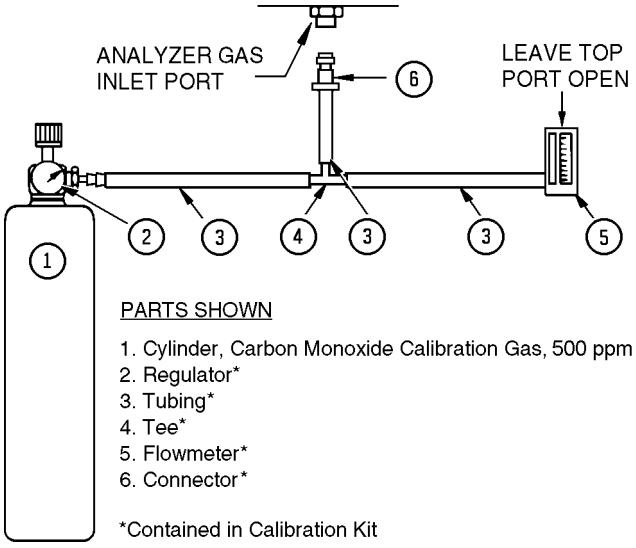


Figure 4-7. CO Sensor Calibration Setup

5. Press the left SELECT key until the CO (ppm) indicator is lit.

6. Connect calibration setup to the instrument. Then adjust regulator on gas cylinder for a flowmeter indication of 0.5 to 1 SCFH.

7. Allow gas to flow 2 minutes, then read CO concentration on the combustion analyzer's left display. Compare this indication to the CO calibration concentration stamped on the gas cylinder.

8. Using a potentiometer adjustment tool, adjust CO Span pot R9 (Fig. 4-6) until the analyzer's CO indication matches the gas cylinder's concentration value.

9. Shut off regulator and remove gas line. Then while monitoring the CO concentration display, allow the pump to run until the CO display is reduced to zero.

10. Press RUN key to stop pump; then reconnect filter/trap to the analyzer's gas inlet.

11. If no other calibration adjustments are to be made, replace the control panel and printer (if applicable).

4.3.2 Optional NO_X & SO_2 Span Calibration

The optional NO_X and SO_2 sensors are calibrated and installed at the factory. Should you have reason to suspect the accuracy of either sensor, BACHARACH recommends that the unit be sent to a qualified Service Center (see the inside back cover) for calibration. If you have the qualified facilities and personnel to make the calibration, span the sensors using a procedure similar to the CO Span Calibration procedure described in Section 4.3.1 substituting the appropriat gas (typically 100 ppm NO or 100 ppm SO_2). Fig. 4-6 shows NO_X and SO_2 span potentiometer locations.

WARNING!

Due to the highly toxic nature of the gases required to calibrate the NO_X and/or SO_2 sensor(s), only attempt to replace or calibrate these sensors if you are trained in the use and handling of toxic gases; otherwise, these sensor(s) should be replaced and calibrated by an authorized Bacharach Service Center.

4.4 THERMOCOUPLE SPAN CALIBRATION - R19

Two thermocouple calibration procedures are provided. The first procedure under Section 4.4.1, which uses boiling water as the calibration-temperature source, is relatively easy to perform, and provides thermocouple accuracy up to 1400°F (760°C). The second procedure under Section 4.4.2, which uses a mV source to simulate a calibration temperature of 1700°F (927°C), is more complicated to perform, but ensures thermocouple accuracy up to 2000°F (1093°C).

4.4.1 Low-Range Thermocouple Calibration Up to 1400°F (760°C)

This procedure calibrates the probe's thermocouple to be accurate up to a temperature of 1400°F (760°C). Note that a thermocouple calibrated using this procedure can be used at higher temperatures, but its accuracy may be slightly compromised.

NOTE: *The Ambient Temperature Calibration pot, R24, must be adjusted to its correct setting before Thermocouple Span pot R19 can be adjusted.*

Equipment Needed (See Section 6 for Part Numbers)

- Thermometer, precision grade, 0° to 220°F (–20° to 150°C)
- Boiling Water Bath
- Potentiometer Adjustment Tool

Procedure

1. Remove filter/trap.

   Important: *This step prevents boiling water from being sucked up through the probe.*

2. Remove control panel per Section 4.1.

3. Power up the analyzer as follows:

   a. Turn on the analyzer by either plugging it in, or by setting its battery pack switch to ON.

   b. Press CAL key to start the 60 second calibration cycle.

   c. When the word FUEL appears on left display, press FUEL key to select any one of the seven fuels.
   d. Press RUN key to start analyzer.

4. Press left SELECT key until TEMP indicator is lit.

5. Immerse probe tip and thermometer into a bath of boiling water (Fig. 4-8).

6. Wait 60 seconds to allow the thermocouple temperature to stabilize; then read the water temperature on the combustion analyzer's left display. Compare this reading to the temperature indication on the thermometer.

7. Using a potentiometer adjustment tool, adjust Thermocouple Span pot R19 (Fig. 4-6) until the analyzer's temperature readout matches the thermometer's temperature indication.

8. Remove probe from boiling water; press RUN key to stop analyzer.

9. Replace filter/trap; then if no other calibration adjustments are to be made, replace control panel and printer (if applicable).

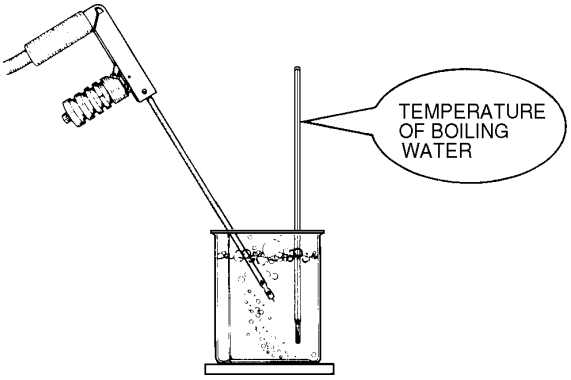


Figure 4-8. Low-Temperature Range Thermocouple Calibration Setup

4.4.2 High-Range Thermocouple Calibration Up to 2000°F (1093°C)

This procedure calibrates the probe's thermocouple to be accurate up to a temperature of 2000°F (1093°C).

> **NOTE:** *The Ambient Temperature Calibration pot, R24, must be adjusted to its correct setting before Thermocouple Span pot R19 can be adjusted.*

Equipment Needed (See Section 6 for Part Numbers)

- Potentiometer Adjustment Tool
- Temperature Calibration device (e.g. Omega Model CL23), **or**
  - Thermometer for measuring ambient temperature,
  - mV Source,
  - K-Type Thermocouple Wire
  - K-Type Thermocouple Connector
  - Potentiometer Adjustment Tool

Procedure

1. Remove filter/trap and thermocouple plug from control panel.

2. Remove control panel per Section 4.1.

3. Power up the analyzer as follows:

   a. Turn on the analyzer by either plugging it in, or by setting its battery pack switch to ON.

   b. Press CAL key to start the 60 second calibration cycle.

   c. When the word FUEL appears on left display, press FUEL key to select any one of the seven fuels.

   d. Press RUN key to start analyzer.

4. Press left SELECT key until TEMP indicator is lit.

5. Connect temperature calibration device or mV source to control panel thermocouple socket using K-type thermocouple wire per Fig. 4-9.

6. Refer to Table 4-1 and adjust mV source for an output that corresponds to the ambient temperature.

7. Adjust R19 (Fig. 4-6) until 1700°F (927°C) is displayed.

8. Press RUN key to stop analyzer.

9. Remove mV source; then if no other calibration adjustments are to be made, replace the control panel and printer (if applicable).

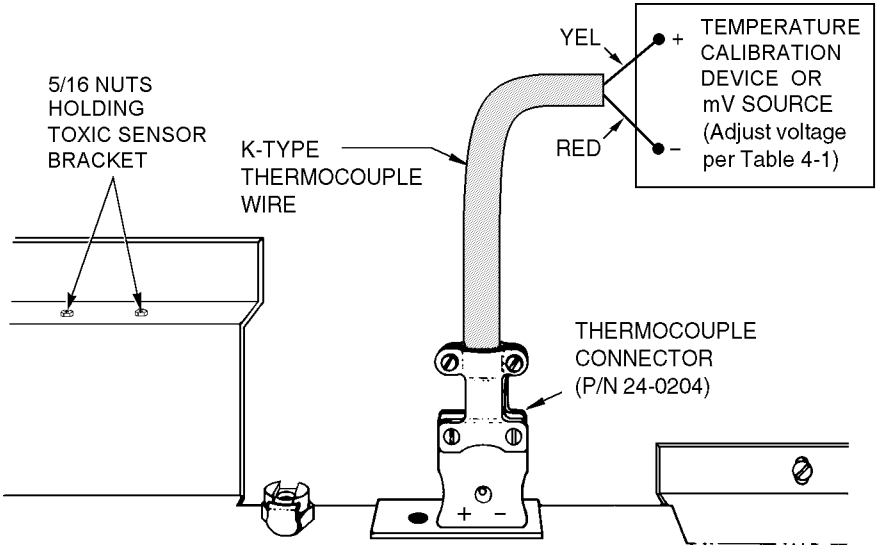


Figure 4-9. High-Temperature Range Thermocouple Calibration Setup

TABLE 4-1.
MV LEVEL VS. AMBIENT TEMPERATURE FOR THERMOCOUPLE CALIBRATION @ 1700°F (927°C)

Ambient Temp °F (°C)	mV Applied
60 (16)	37.8
70 (21)	37.5
80 (27)	37.3
90 (32)	37.1
100 (38)	36.9

4.5 OXYGEN SENSOR CALIBRATION

The oxygen sensor does not require manual calibration. Automatic calibration to an oxygen level of 20.9% occurs each time the combustion analyzer runs through its calibration cycle – the microprocessor assumes fresh air is being sampled during calibration.

During the calibration cycle, the middle display shows the millivolt output of the oxygen sensor. If this output indication is below 18, the oxygen sensor is nearing the end of its useful life and should soon be replaced.

If the microprocessor senses that the oxygen sensor's output is less than 15.1 mV or greater than 65.9 mV during calibration, the first display will show an **E*O2** error after the conclusion of the calibration cycle. Also, if the oxygen cell's output exceeds 74.4 mV during calibration or during a combustion efficiency run, the first display will shown an **OR/O** over-range and stop the instrument. Refer to Section 3.5 for information on what to do if an **E*O2** or **OR/O** message appears.

5 MAINTENANCE

This section describes how to:

- Remove the Sensor Cover
- Replace the Oxygen Sensor
- Replace the Toxic Sensors
- Replace the Filter/Trap Filter Element
- Clean the Gas-Sampling System
- Perform a Leak Test
- Replace the Printer Paper
- Replace the Optional Bias Batteries
- Configure the Analyzer Using its Optional Internal Switches

Maintenance work, other than that noted above, should be performed by an authorized Bacharach Service Center. Any maintenance performed by an unauthorized service organization will void the instrument's warranty and release Bacharach, Inc. of any implied or written product liability.

5.1 OXYGEN SENSOR REPLACEMENT

Equipment Needed (See Section 6 for Part Numbers)

- Replacement Oxygen Sensor
- Scissors
- Screwdriver, 3/16" Blade

Procedure

WARNING!

Burn hazard. The oxygen sensor contains corrosive chemicals. DO NOT puncture or take the sensor apart.

1. Remove sensor cover per Section 4.1.

2. See Fig. 5-1. Using a small screwdriver, remove the two screws from the oxygen sensor flange, and then remove flange.

3. Rotate oxygen cell counterclockwise until it is free of the four electrical contacts on the oxygen cell base. Then remove and discard old sensor. Make sure O-Ring is still in Oxygen cell Base.

4. The new oxygen sensor is shipped in a foil envelope. Use scissors to cut open the envelope and remove the sensor.

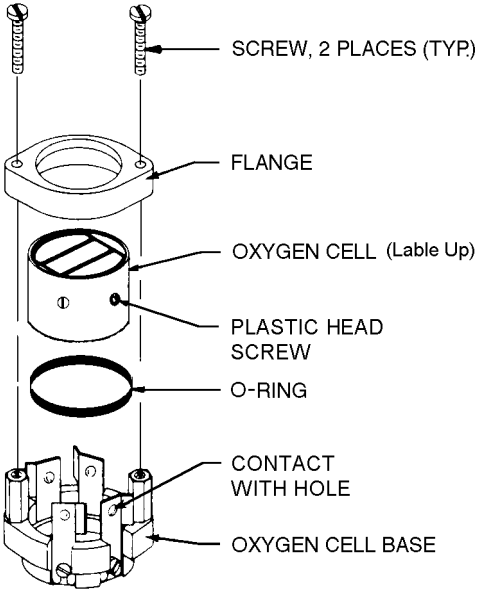


Figure 5-1. Oxygen Sensor Replacement

5. Look at the contacts on the oxygen sensor base. Three contacts have dimples and one has a hole. Line up the oxygen sensor (mesh end toward the base) so that its plastic screw is just to the right of the contact with the hole. Rotate the sensor clockwise until its three stainless steel screwheads are seated in the dimples, and its plastic screwhead protrudes through the hole. When positioned properly, the label on the rear of the sensor should be readable.

6. Position flange over rear of sensor; then insert two screws and tighten with a screwdriver. *DO NOT* overtighten these screws!

7. Replace sensor cover.

5.2 TOXIC SENSOR REPLACEMENT

Equipment Needed (See Section 6 for Part Numbers)

- Nutdrivers, 4 mm (5/32"), & 8 mm (5/16")
- CO Sensor, or
- NO_X Sensor, or
- SO_2 Sensor

Procedure

WARNING!

Burn hazard. The carbon monoxide sensor contains corrosive chemicals. DO NOT puncture or take the sensor apart.

1. Remove sensor cover per Section 4.1.

   NOTE: *The optional SO_2 and NO_X sensors are located directly beneath the O_2 and CO sensors. In order to remove these sensors, their mounting bracket must be removed first. This requires removing the two 5/16 nuts, see Fig. 4-9.*

2. Using a 5/32 nutdriver, *loosen* nuts that secure the wires connected to Toxic sensor terminals C, S, and R (Fig. 5-2); then remove the wires.

3. Remove the 5/32 nuts that retain the Toxic sensor to its expansion chamber; then remove and discard the old Toxic sensor.

4. Before proceeding, ensure that the Toxic sensor's O-ring and membrane are still positioned inside the expansion chamber.

5. Remove new Toxic sensor from its shipping container and place it over the screws that protrude up from the expansion chamber. When positioned properly, the sensor's three electrical connections should be facing up and toward the front of the analyzer.

   NOTE: *The new CO and SO_2 sensors will have a shorting wire connected between terminals R and S. DO NOT remove this wire until instructed to do so in Step 7.*

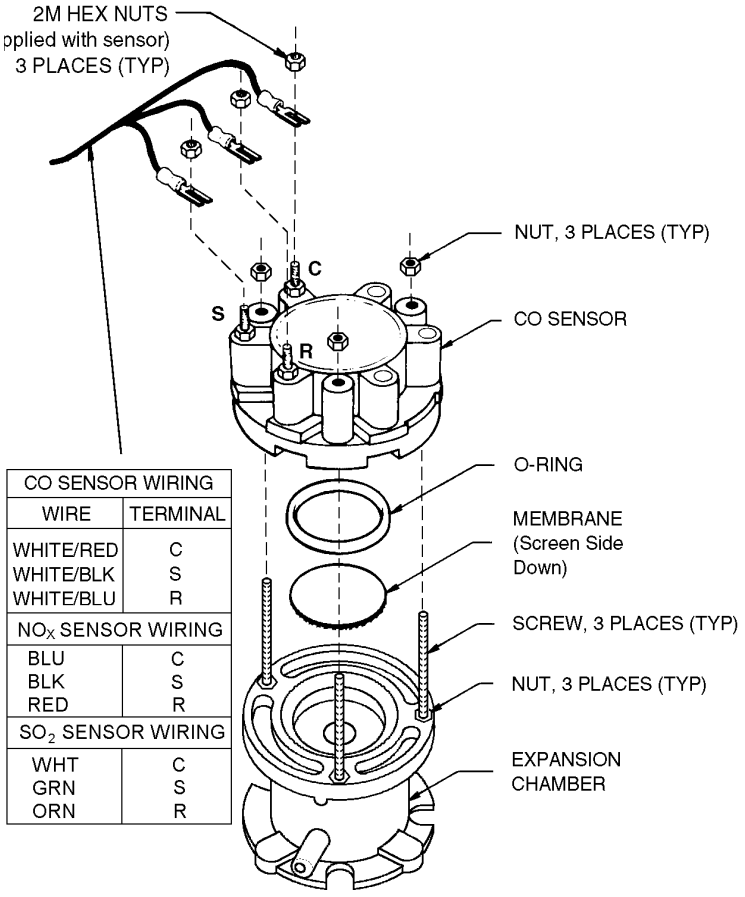
6. Use the three nuts removed in Step 3 to secure the sensor to the expansion chamber. *DO NOT* overtighten these nuts!

7. Remove shorting wire from CO and/or SO_2 sensor terminals R and S.

8. Loosen nuts on sensor terminals C, S and R; then connect wires from analyzer to the sensor as shown in Fig. 5-1. Tighten these connections with a nutdriver. *DO NOT* overtighten connections!

9. Replace sensor cover.

10. Calibrate the new Toxic sensor per Section 4.3 (See Table 5-1 for NO_X stailization time prior to calibration).



CO SENSOR WIRING	
WIRE	TERMINAL
WHITE/RED	C
WHITE/BLK	S
WHITE/BLU	R
NO_X SENSOR WIRING	
BLU	C
BLK	S
RED	R
SO_2 SENSOR WIRING	
WHT	C
GRN	S
ORN	R

Figure 5-2. Toxic Sensor Replacement

5.3 FILTER/TRAP FILTER REPLACEMENT

The filter element within the panel mounted filter/trap should be replaced whenever it appears clogged, or becomes a restriction in the sampling system. Water soaked filters can be air dried, and do not necessarily require replacement.

Equipment Needed (See Section 6 for Part Numbers)

- Replacement Filter

Procedure

1. If the analyzer's pump is running, stop the pump by pressing the RUN key. Then wait 10 seconds before removing the filter/trap assembly to allow the pressure within the assembly to equalize.

2. Remove filter/trap from control panel.

WARNING!

Water inside the filter/trap may be hot and mildly acidic. Take the necessary precautions to avoid being burned.

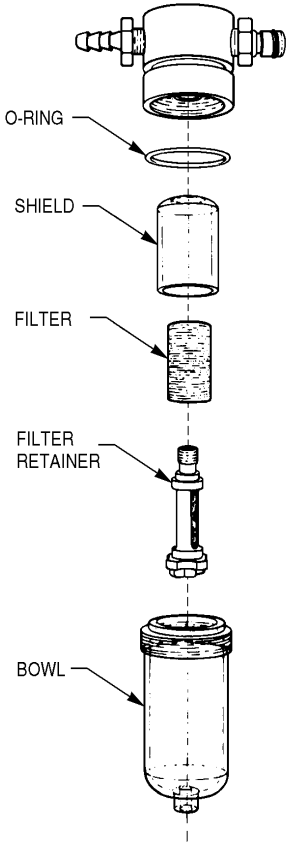
CAUTION:

DO NOT use solvents to clean the filter/trap's plastic bowl, as they can attack plastic and damage the bowl.

3. See Fig. 5-3. Unscrew and empty the bowl. If the bowl appears dirty, it may be washed in a soap and water solution.

4. Unscrew the filter retainer. The filter element and its clear plastic shield will come off with the retainer. Discard old filter element.

5. Install a new filter element and reassemble the filter/trap assembly.



NOTE: *Make sure that the open end of the shield is facing down.*

Figure 5-3. Filter/Trap Filter Replacement

5.4 CLEANING THE GAS SAMPLING SYSTEM

If the combustion analyzer is used on either coal or oil fired burners, particulates can accumulate within the probe and sampling hoses. These particulates may, in time, build up and cause a restriction in the gas sampling system. While using the combustion analyzer, the type of fuels that cause the most dirt and how often the system needs to be cleaned will become evident.

5.4.1 Cleaning the Probe and its Sampling Hose

Equipment Needed

- Small Allen-Wrench Set
- Hammer
- Center Punch
- Open-End Wrench, 1/2"
- Particulate Trap Key Wrench (supplied with analyzer)
- Gallon Bucket Filled with Clean Water
- Alcohol
- Mild Detergent
- Pipe Cleaners
- Clean Rags
- Method of forcing water through probe's sampling hose (see text)
- Source of Compressed Air (optional)

Procedure

1. Turn off analyzer.

WARNING!

The probe's particulate trap may contain hot and mildly acidic water. Take the necessary precautions to avoid being burned.

2. Remove sampling hose from filter/trap, and unplug thermocouple connector from control panel.

3. See Fig. 5-4 and disassemble the probe in the following manner:

   a. Using a hammer and center punch, remove roll pin.

   b. Using Allen wrenches, remove Allen screws that secure probe-tube retainer to probe handle.

   c. Remove gas sampling hose from particulate trap.

d. Using an open-end wrench, loosen thermocouple nut from particulate trap. Then slide probe tube and particulate trap off thermocouple.

e. Using an open-end wrench, loosen probe-tube retainer and remove probe tube from particulate trap.

f. Unscrew knurl nut from bottom of particulate trap. Then use the particulate-trap wrench to unscrew the screw cap (Fig. 3-6 shows usage of wrench).

4. Clean probe tube by flushing it with a detergent and water solution. Then rinse with clean water.

5. Using pipe cleaners and a clean rag soaked with a mild detergent, clean the interior and air passages of the particulate trap. Then rinse particulate trap with clean water.

6. Dampen a clean rag with alcohol and carefully wipe the thermocouple wire clean.

7. *With the sampling hose disconnected from the filter/trap,* squirt a few drops of detergent into one end of the sampling hose. Force water through the hose until all detergent is removed. (A faucet adapter connected to a small piece of rubber hose may be used to supply a rapid flow of water through the sampling hose.)

8. *Thoroughly dry* all probe parts and the sampling hose before reassembling the probe. Compressed air may be sprayed through the probe and sampling hose to speed drying.

9. See Fig. 5-4 and reassemble the probe as follows:

   a. Install O-ring, screw cap, and knurl nut with washer at bottom of particulate trap.

   b. Install probe tube onto particulate trap and tighten probe-tube retainer using an open-end wrench.

   c. Slide particulate trap and probe tube over thermocouple. Use an open-end wrench to tighten thermocouple nut. *Be careful not to break thermocouple-wire seal.*

d. Attach gas sampling hose to particulate trap. Dress the sampling hose and thermocouple wire neatly to prevent kinking the hose.

e. Install particulate trap, probe tube, and roll pin in probe handle. Position particulate trap so that its tee fitting rests on top of the roll pin.

f. Attach probe-tube retainer to probe handle using two Allen screws. If necessary, loosen bottom Allen screw and move retainer to align screw holes.

10. Attach sampling hose to filter/trap, and plug thermocouple connector into control panel.

11. Leak test probe as described in Section 5.5.

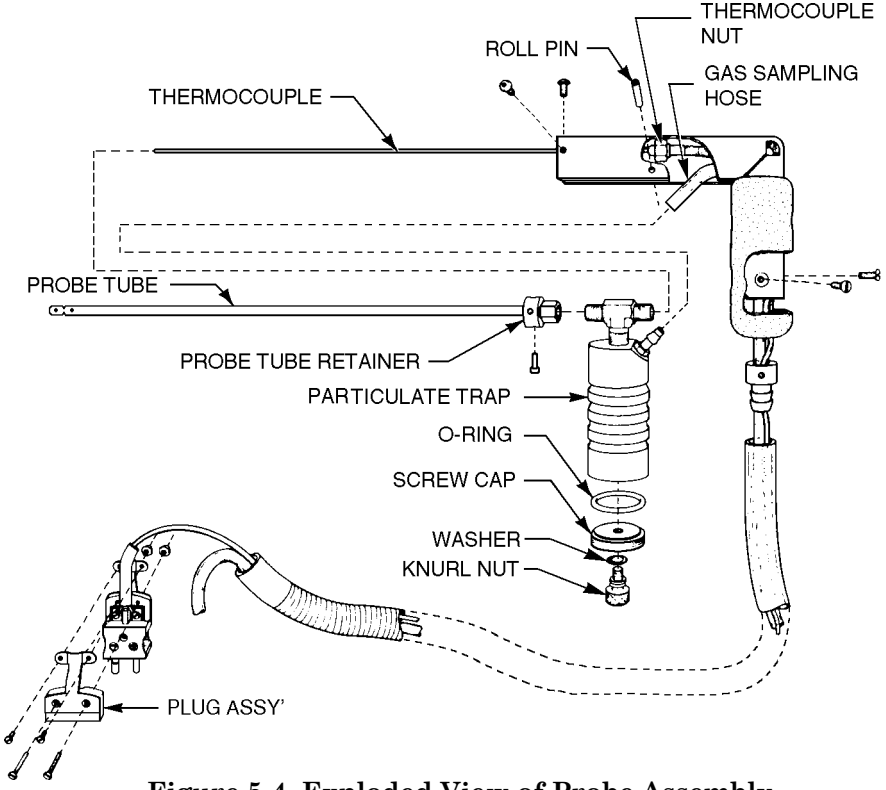


Figure 5-4. Exploded View of Probe Assembly

5.4.2 Cleaning the Analyzer's Sampling System

Equipment Needed

- Screwdriver, 1/4" Flat-Blade
- Pipe Cleaners
- Jumper Wire with Alligator Clips
- Water
- Mild Detergent
- Clean Rag

Procedure

1. Turn off analyzer.

2. From rear of control panel, remove filter/trap from its quick-connect socket, and unplug thermocouple connector.

3. Remove the sensor cover (see Section 4.1), and remove the O_2, and CO sensors. If the optional SO_2 and NO_X sensors are installed, remove the control panel using Section 4.1, and remove them. Temporarily connect a jumper wire to the CO and optional SO_2 sensors terminals R and S.

   Important! *In the following step, DO NOT remove the wires from the CO or the Optional SO_2 sensors. If the electrical connections are removed and then reconnected to these sensors, a restabilization time period of up to several hours is required before the sensors stabilize (see Section 5.7). The longer the sensors are disconnected from the analyzer, the longer the restabilization period becomes.*

   NOTE: *Since the analyzer has all sensors mounted in an* ***pright*** *position, the sensor-mounting bracket that is located directly below the O_2 and CO sensors must be removed from the front-panel assembly before SO_2 and/or NO_X sensor(s) can be removed.*

4. Remove the control panel, if not already removed, (refer to Section 4.1) and place it on a clean work surface.

5. Clean surfaces of oxygen sensor base and carbon monoxide expansion chamber with a clean rag.

CAUTION:

DO NOT clean or disassemble the pump. The pump's check valves are delicate and may be damaged if cleaned.

6. Disconnect sampling hoses from fittings marked in Fig. 5-5 and clean these fittings with a pipe cleaner soaked in a mild detergent. Remove detergent with another pipe cleaner soaked in water, and then dry the fittings with a dry pipe cleaner.

7. If sampling hoses look dirty, remove hoses from analyzer and swirl them around in a detergent and water solution. *Thoroughly rinse and dry* the hoses, and then reinstall them inside the analyzer.

8. After cleaning the analyzer's sampling system reinstall the filter/trap, thermocouple plug, oxygen sensor, carbon monoxide sensor (jumper removed), sensor bracket (if removed), and sensor cover onto the control panel. Finally, reinstall the control panel (Refer to Sections 2.3, 2.4, 4.1, 5.1, and 5.2.)

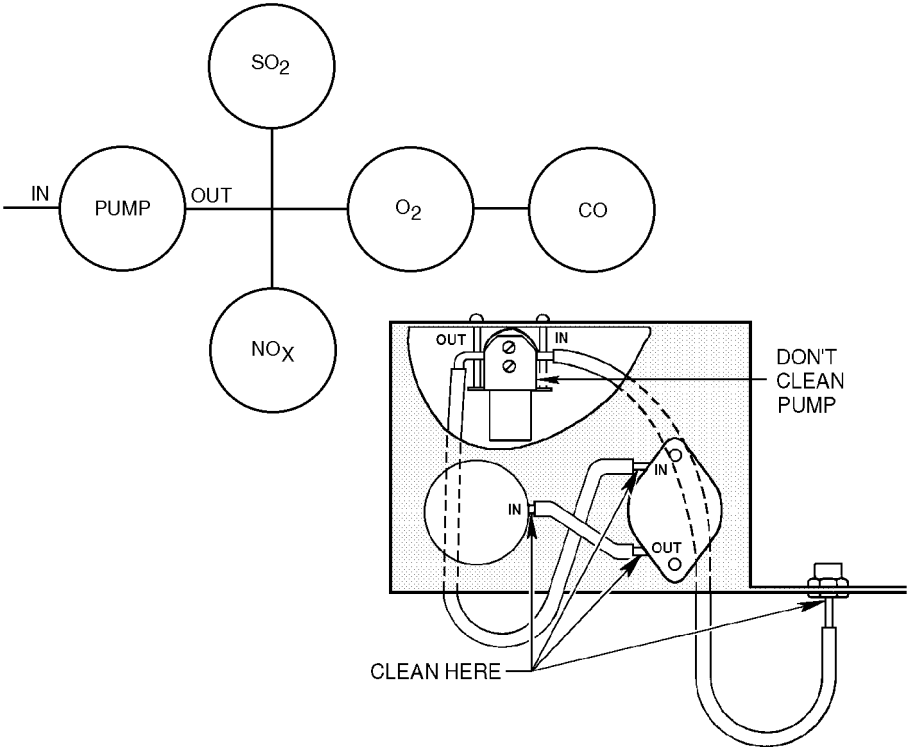


Figure 5-5. Combustion Analyzer Hose Routing & Fittings

5.5 LEAK TESTING

After cleaning and reassembling the probe, it is good practice to ensure that no leaks have developed. A leak can draw air into the system, thus increasing the O_2 indications for flue gases and diluting the flue gases for CO, NO_X and SO_2 measurements. A leak will also cause a lower than actual efficiency computation.

Equipment Needed

- Soap and Water Solution
- Small Brush

Procedure

1. Remove control panel (refer to Section 4.1) and place it on a clean work surface.
2. Reverse tubing connections at pump (see Fig. 5-5).
3. Seal end of probe so that it's air tight.
4. Turn on analyzer; then press CAL key.
5. Brush soapy water over the now pressurized connections of the probe assembly. If necessary, disassemble the probe and repair any leaks found.
6. Turn off analyzer; restore original tubing connections at pump; then reinstall control panel.

5.6 PRINTER PAPER REPLACEMENT

Equipment Needed (See Section 6 for Part Numbers)

- Replacement Paper Roll

Procedure

1. Open the printer by pressing its spring-loaded latch on the left-hand side of the printer's front panel. See Fig. 5-6.

2. The paper-roll carrier is mounted on the rear of the printer's front panel and will swing out when the printer is opened.

3. Pinch in the two paper-roll clips at the end of the paper carrier, and then remove the empty roller from the carrier.

4. Install a new paper roll onto the paper carrier.

5. With the analyzer turned on, present the paper to the entry point at the lower edge of the printer's feed mechanism. The paper will be sensed by the mechanism and be automatically fed through the printer and into the proper position for printing.

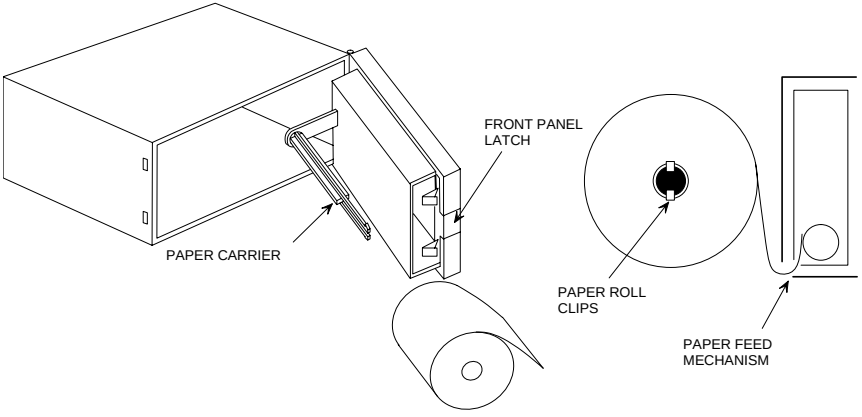


Figure 5-6. Installing Printer Paper

5.7 OPTIONAL SENSOR BIAS BATTERY REPLACEMENT

Four "AA" batteries mounted behind the control panel apply a constant bias voltage to the NO_X and/or SO_2 sensor(s). The batteries should last a minimum of 6 months, with a typical life expectancy of 9 months to more than 1 year.

Replace the batteries when the LOW BATT message appears on the auxiliary display panel. You have approximately 1 month of operating time left after the first LOW BATT message is displayed before the batteries go completely dead, as indicated by the BATT FAIL message.

Replace the batteries as follows:

Equipment and Materials Needed:

- Medium Flat-Blade Screwdriver
- Four "AA" Alkaline Batteries

Procedure:

1. Remove control panel per Section 4.1 in this manual.

2. Tilt the control panel upwards until the four "AA" batteries become accessible (Fig. 5-7).

3. Replace batteries with four fresh "AA" alkaline cells in the proper polarity.

   If batteries are installed incorrectly, the BATT FAIL message appears on the auxiliary-display panel after analyzer is powered on and run through its calibration cycle.

   The SO_2 sensor stabilizes within 15 minutes after the application of bias voltage.

   Depending on how long the NO_X sensor was without bias voltage, the time required for this sensor to stabilize varies from less than a minute to several days. Typical stabilization times are shown below:

Table 5-1. Typical NO_X Stabilization Times

Bias removed*	Stabilization Time
Less than 15 min.	Less than 1 min.
Less than 1 hr.	Less than 5 min.
Less than 2 days	Less than 4 hr.
Greater than 2 days	Up to 2 days

***** *Due to dead or missing batteries.*

4. Reinstall the control panel and the auxiliary-display panel.

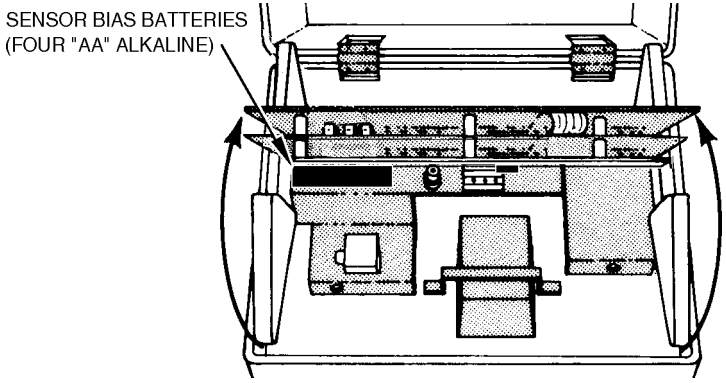


Figure 5-7. Optional Bias Battery Location

5.8 OPTIONAL DIP SWITCH SETTINGS

The settings of the analyzer's internal switches select which sensors are active when installed; which language is used on the printout; and which RS-232 port settings are in effect when using an external serial device.

> **NOTE:** *Any new switch settings do not take affect until the instrument goes through a power off/on cycle.*

To set the switches, proceed as follows:

1. Remove control panel per Section 4.1 in this manual.

2. Tilt control panel upwards until the DIP switch becomes accessible (Fig. 5-8).

3. See Fig. 5-9. To **enable** or turn **on** a function, set its corresponding switch to ON. Note, however, the language and baud rate settings require the setting of two switches.

4. After setting switches, replace control panel.

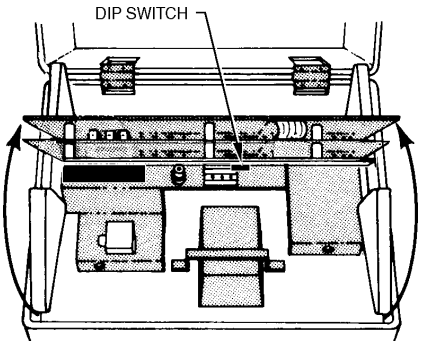


Figure 5-8. Optional DIP Switch Location

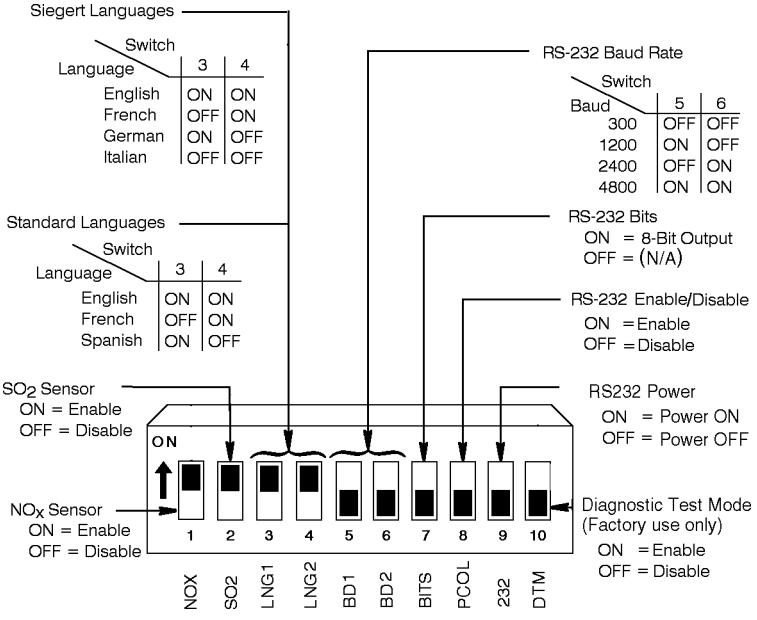


Figure 5-9. Optional DIP Switch Settings

6 REPLACEMENT PARTS, ACCESSORIES, AND DIAGRAMS

This Section contains the following information:

- Replacement Parts List
- Accessories List
- Wiring Diagram

6.1 REPLACEMENT PARTS LIST

Item	Part Number
AC Power Supply:	
120 VAC Input	304-1706
240 VAC Input	24-0508
Battery Pack	24-0537
Battery Charger:	
12 VDC Input	24-0527
240 VAC Input	24-0528
120 VAC Input	24-0529
Control Panel Screw	01-7276
Filter/Trap Assembly:	
Complete Assembly	24-0642
Filter (Box of 3)	24-0683
Instruction Manual	24-9223
Printer Assembly:	
Printer	24-0995
Paper (box of 5 rolls)	24-0980
Printer Screw	01-7096
Probe Assembly:	
Complete Assembly	24-7131
Knurled Nut	102-0876
O-Ring	05-5124
Particulate Trap	24-0477
Plug, K-Type (yellow body)	24-0615
Probe-Stop	24-0434
Trap Plug	24-0485

6.1 REPLACEMENT PARTS LIST (CONT.)

Item	Part Number
Probe Assembly (Cont.)	
Thermocouple, K-Type	24-0613
Washer	05-6326
Wrench	21-0078
Pump and Motor Assembly	24-0500
Sensor Assemblies:	
Oxygen Sensor Assembly:	
Flange	51-1206
Oxygen Cell Base	51-1207
Oxygen Sensor	24-0108
O-Ring	05-5207
Screw, #6-32 x 3/4" lg.	01-6899
Toxic Sensor Assembly:	
Carbon Monoxide Sensor	24-0498
Expansion Chamber	24-0495
Nut, M2 Hex	502-0063
Optional NO_x Sensor	19-8001
Optional SO_2 Sensor	19-8002
O-Ring and Membrane	24-0520
Screw, M2 x 25 mm lg.	501-3808

6.2 ACCESSORIES LIST

Item	Part Number
CO Gas Cylinder, 100 ppm	51-1994
CO Gas Cylinder, 500 ppm	24-0492
K-Type Extended Hose Assy':[1]	
10 ft.	24-7127
20 ft.	24-7128
K-Type Extended Probe Assy':[2]	
24 in.	24-7126
36 in.	24-7125
48 in.	24-7124
Portable CO Calibration Kit (NO Gas)	24-7059
Potentiometer Adjustment Tool	06-9453
Thermocouple Plug	24-0204
True Spot Smoke Test Set	21-7006
(Storage space is provided inside the combustion analyzer case for the True Spot Smoke Tester.)	

[1] Extended Hose assemblies can be combined to produce a maximum recommended length of 50 ft..

[2] An Extended Probe assembly cannot be connected to the analyzer without also installing one of the Extended Hose assemblies

6.3 WIRING DIAGRAM

Figure 6-1A shows the wiring diagram of the Model 300 Combustion Analyzer. This diagram will be useful to an experienced technician when servicing the analyzer.

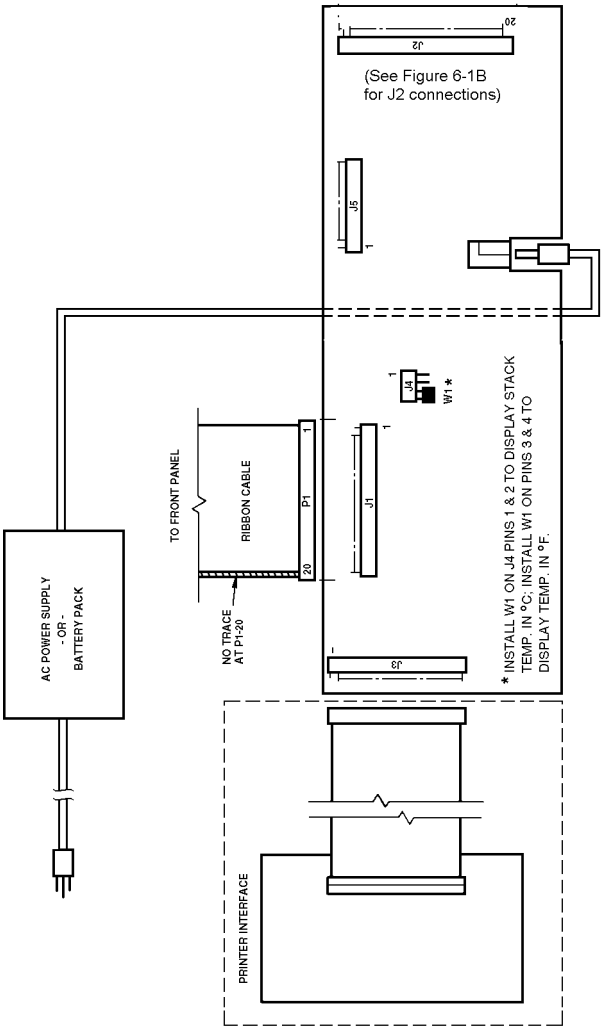


Figure 6-1A. Wiring Diagram

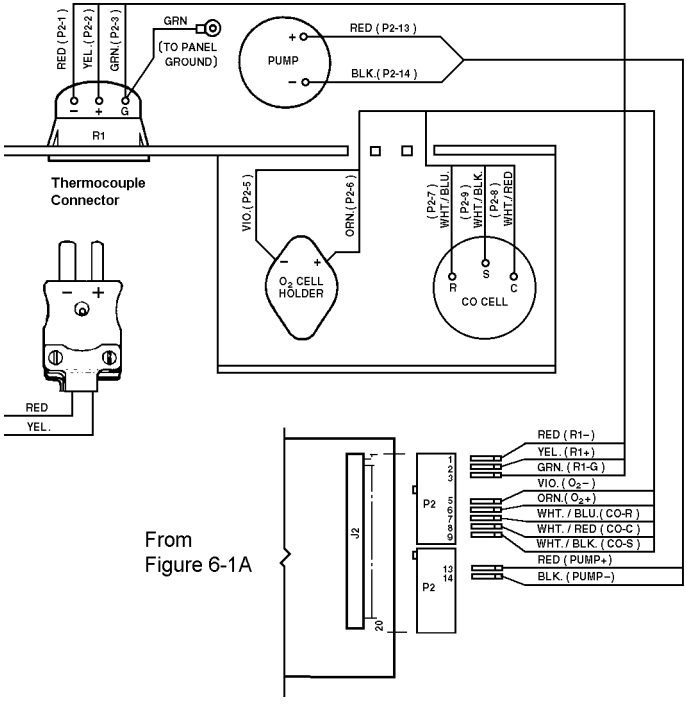


Figure 6-1B. Wiring Diagram

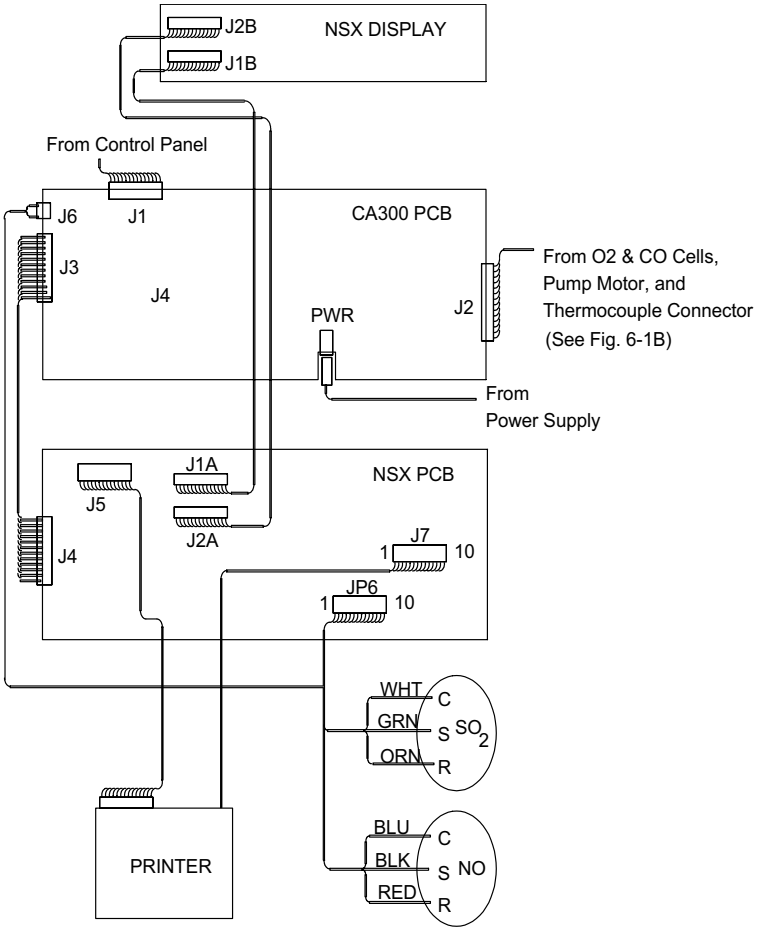


Figure 6-1C. Wiring Diagram (with Optional NSX)

GLOSSARY OF TERMS

AMBIENT AIR
The atmosphere external to the furnace, appliance or process.

CALIBRATION
Comparison of an instrument of lesser accuracy with another standard of known accuracy (calibration gas) to detect, correct and adjust for instrument accuracy.

CARBON DIOXIDE, (CO_2)
A colorless gas, heavier than air, formed by the complete combustion of carbon, and the Chemical symbol for Carbon Dioxide.

COMBUSTION EFFICIENCY
Percent of the available fuel energy that the furnace turns into useful heat.

CONDENSING FURNACE
A high efficiency furnace where water vapor, generated by the combustion process, is condensed and its latent heat of vaporization recycled back into the furnace's heat exchanger.

EXCESS AIR
Quantity of air in excess of the amount required in the perfect theoretical fuel/air mix (stoichiometric mix) that the furnace burns. When tuning a furnace the object is to run the burner at the minimum percentage of excess air that will provide clean (virtually smokeless and CO free) flue gases.

FLUE
A passageway for conveying the combustion products to the outside air.

FLUE GASSES
Gaseous products of combustion.

HEAT EXCHANGER

A device that transfers heat from one system to another, such as in a warm air furnace.

NON-CONDENSING FURNACE

A standard furnace which does not recycle the heat of the vaporized water.

OXIDES OF NITROGEN (NO_X)

The sum of NO (Nitric Oxide) and NO_2 (Nitrogen Dioxide).

PRIMARY AIR

Air mixed with the fuel inside the burners. Primary Air Temperature can be greater or less than Ambient Air Temperature.

SECONDARY AIR

Air for combustion supplied to the outside of the flame to supplement the primary air.

SO_2

The chemical symbol for Sulfur Dioxide.

STACK LOSS

Percent of the available fuel energy that the furnace wastes through transport in the stack gases.

STOICHIOMETRIC MIX

Perfect theoretical fuel/air mix. Not practical for combustion equipment. “Real world” equipment requires an certain amount of excess air for complete combustion.

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